APRIL 27

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Vinyl-Metal Laminates

Contents, Page 3

FARNSWORTH

No place for guessing games!

The right choice of materials is certain when you bring your bearing problems to Bound Brook. Choosing from over 25 grades of sintered iron and bronze, our powder metallurgy engineers select the material with exactly the right properties for *your* application . . . the right balance of hardness, strength, ductility, density and thermal conductivity to fit your needs. They can create many special properties for you, too, by varying the composition of the metal powders. Your choice is always right when you choose Bound Brook for your bearings.

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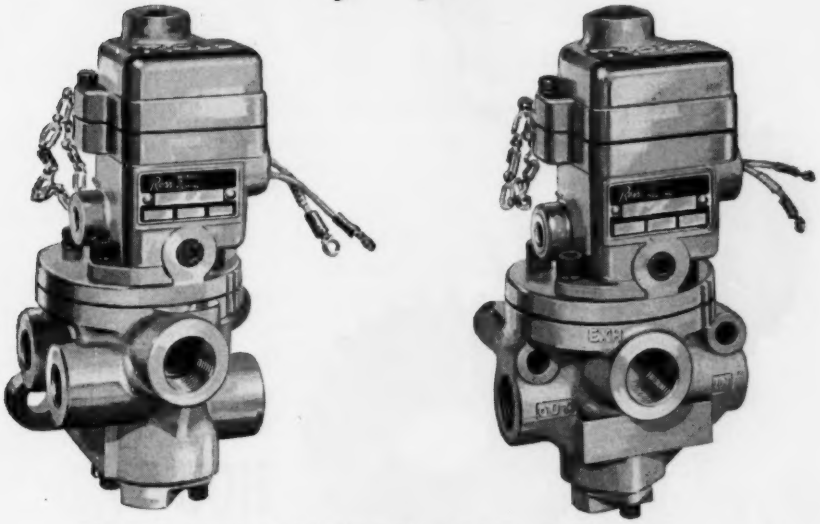
Pioneer in Powder Metallurgy Bearings and Parts • Plants at Bound Brook, N.J. and Sturgis, Mich

Circle 201 on Page 19

THANK YOU . . .
for your enthusiastic response to this announcement. Because it has been viewed as an important advance in valve development, we reprint this news for those who missed its first appearance.

Ross

Proudly presents



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When the price, quality and performance and Ross reputation are taken together in evaluating this series, it represents probably the best valve value available today. Before you specify any valve after today, you owe it to yourself to look into the "Headline" series. Write for full information.

Ross OPERATING VALVE COMPANY

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By switching to a lead-treated steel, Thor Power Tool Company cut the cost of these idler gears in half. Aristoloy 4620 (leaded*) provided high strength with excellent wear and shock resistance qualities. On gear cutting operations, machinability jumped from 35% to 66% (of B 1112). And there was a marked improvement in surface finish.

If you would like to know more about the production economies of lead-treated steels possible on hobbing, broaching, milling, and particularly automatic machining operations, write today for LEADED STEELS CATALOG. Or call your nearest Copperweld representative.

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Front Cover: The formability of vinyl-metal laminates provides the centerpiece for George Farnsworth's cover. In the article starting on Page 102, author James K. Baker tells the colorful story of these versatile prefinished materials.

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IN THE NEXT ISSUE: Using outside R & D . . . laminated-plastic and vulcanized-fiber parts . . . push-pull controls . . . preventing fatigue failures . . . fhp motors . . . hydraulic-system temperatures.

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

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A-X TUBING

Anaconda A-X tubing is a flexible metal connector with annular corrugations designed to handle the types of movement shown at the right while conveying liquids or gases. It is available in stainless steel and other alloys and is generally sold complete with fittings (right, below). Nominal tubing I.D.'s: 5", 6", 8", 10", 12", 14".

Most axial motion applications involve motion in one direction in respect to the installed position. This may result in compression or extension of the tubing. In a few applications an assembly may be subjected to both extension and compression in relation to the installed length – such cases occur when temperature varies both above and below installation temperature. In order to give the best service for each type of application there are three different corrugation standards for each tubing size:

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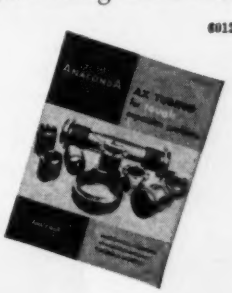

Bulletin A-X 97 gives complete details. Call your Anaconda Metal Hose representative for a copy—or for the services of an Anaconda specialist to help you in the design of a special connector to meet your needs. Or send in coupon below.

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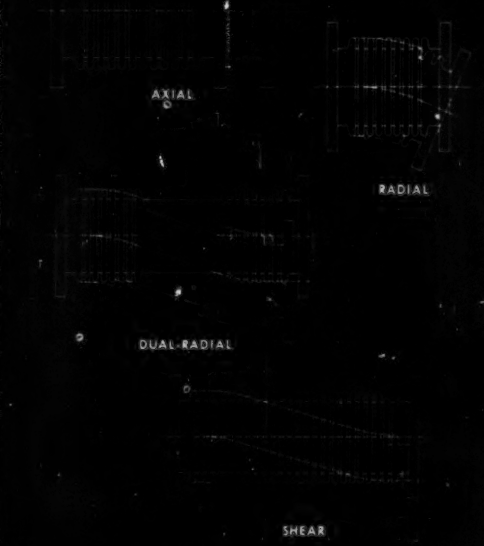
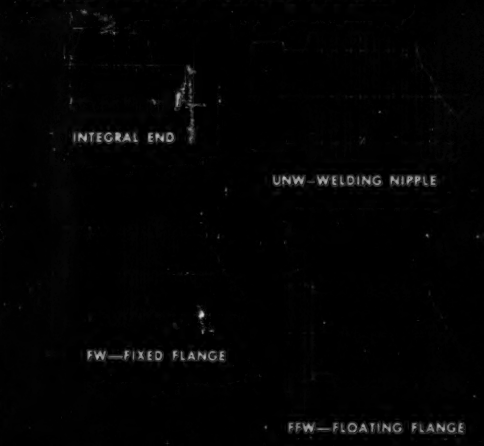
BASIC STANDARD UNIT

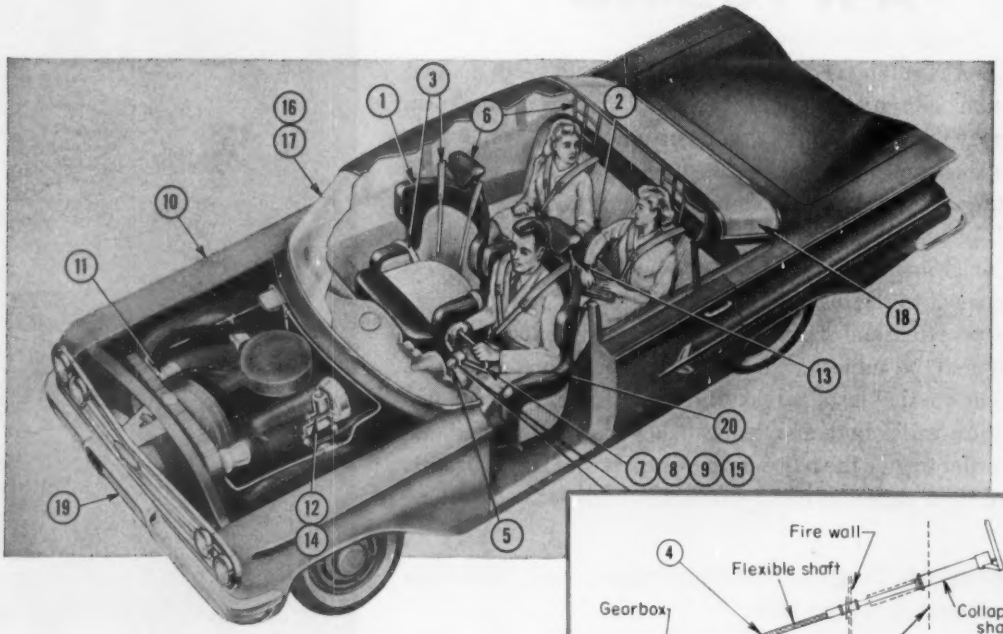
TYPES OF MOTION



FITTINGS FOR A-X TUBING—UNBRAIDED



FITTINGS FOR A-X TUBING—BRAIDED



Made up of piano wires, the flexible steering shaft (above) buckles forward during impact. In addition, a telescoping tube, attached to the dashboard, retracts, allowing the steering wheel to give under the driver's weight. Whip-lash protection is furnished by the padded head rest (below). Roll-over bars, mounted on each capsule chair, provide an extra measure of safety should the car turn over.

Survival by the Numbers

NEW YORK—Driver and passengers in Survival Car II are so well protected that serious crash injuries are virtually impossible. The car, a modified 1960 Chevrolet, was designed by Liberty Mutual Insurance Co. to show how safety can be built into production-line automobiles. It differs from the earlier Survival Car (introduced in 1957) in that no basic structural changes are incorporated. The '57 version featured a specially constructed body.

Safety features (called out above) include: 1. Capsule chairs that withstand a 5000-lb load, 30-g deceleration in a 30-mph collision. 2. Equivalent rear-seat protection. 3. Lap belts and shoulder harnesses. 4.5. Flexible shaft that buckles and steering tube that telescopes in a crash. 6. Whiplash protection. 7.8.9. Small rectangular steering wheel to prevent knee-cap injuries, give greater visibility, and improve maneuverability. 10. Unit body construction with high energy absorption factor. 11. Automatic fire-control system. 12. Fail-safe brakes. 13. Roll-over bars. 14.15. Power brakes and steering. 16.17. Laminated windshield that has high resistance to penetration and eliminates ultra-violet rays. 18. Tinted glass to reduce heat. 19. Reflective license plates. 20. Arm supports to reduce fatigue.

...Fluid Power news

OILGEAR 40 Years of Fluid Power

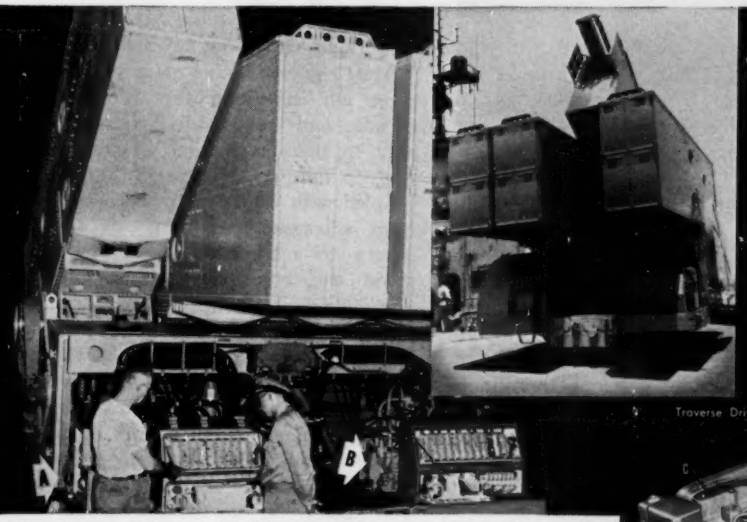
Report No. 11,400 From Oilgear *Application-Engineering* Files

HOW OILGEAR ELECTROHYDRAULIC SERVO-VALVE-CONTROLLED DRIVES AIM *ASROC** MISSILE LAUNCHERS IN RESPONSE TO LOW-POWER SIGNALS FROM SHIPBOARD DIGITAL COMPUTERS.

**ASROC (Anti-Submarine ROCket) — the Navy's deadliest, integrated, anti-submarine weapons system — consists of 4 major parts: an underwater sonar detection device; an electronic, digital, firecontrol (aiming) computer; a "pepper-box" type, 8-missile launcher; and ASROC missiles. Within seconds after sonar detection of a hostile submarine, the computer charts its course, speed, and range — correlated with the ASROC-equipped ship's course, speed, and roll. The resultant computer signals command the launcher to traverse and elevate instantly to accurate "aim" position, and continue to "track" from subsequent computer command signals. The ship commander merely pushes a button to fire either rocket-propelled, homing torpedos or depth charges.*

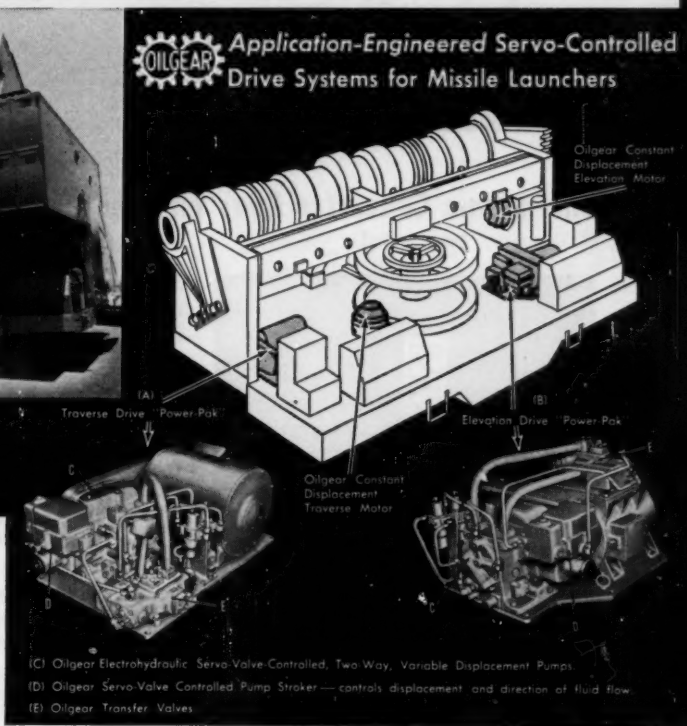
PROBLEM: Power and control for both the traverse and elevation drive systems to "aim" ASROC missile launchers in response to direct, low-power, electrical command signals from a digital firecontrol computer.

REQUIREMENTS: 1. High traverse and elevation speeds in either direction, with shockless reversal, to bring launcher "on target" — rapidly. 2. Fast, accurate control response for high-speed "homing." 3. Precisely controlled, low variable speeds for "tracking." 4. Entire drive and control systems to occupy a minimum of space within the launcher base. 5. Dependability — "no time-out permitted" — a rigid requirement for fleet use. 6. Unitized assemblies preferred, to facilitate installation and replacement.



Official Photos — U.S. Navy. Actual launcher performance data is classified information.

ABOVE: ASROC missile launcher being checked at U.S. Naval Ordnance Plant, York, Pennsylvania. Arrows indicate traverse (A) and elevation (B) *Power-Paks*. **INSET:** ASROC launcher ready to fire aboard U.S.S. Norfolk. Each of the 8 cells serve as missile stowage magazines and launchers — all traverse as a unit . . . each over/under pair of cells elevate individually. 360° launcher traverse is possible, but a quadrant is blocked to protect ship's superstructure. Missiles weigh about 1,000 lbs., are about 15 ft long. Launcher base sketch, right, approximates position of Oilgear Drives.



SOLUTION: With Oilgear's experience in meeting the speed, control, and precise turret and gun performance requirements for U.S. Army tanks, howitzers, and anti-aircraft guns — this missile launcher application was a "natural" for Oilgear *ANY-SPEED* Drives — and the alert, accurate response of Oilgear's Electrohydraulic Servo-Valve-Controlled, Two-Way, Variable Displacement Pumps. Amplified signals up to 5-watts actuate drive controls. Cushioned, full-speed drive reversal. These small, rugged, Oilgear *ANY-SPEED* Pump and Motor Drives easily convert output from constant speed electric motors into the exact, required traverse and elevation speeds, direction, and torque . . . even under high overload conditions. An automatic feedback control compensates for load, voltage, or viscosity changes to accurately maintain computer-selected speeds. Torque transmitted automatically increases or decreases to a point just sufficient to overcome resistance. There's no "wire-drawing," or bypassing of fluid to generate heat or waste power. Both systems are totally enclosed, automatically protected against overload, pressure and flood lubricated to assure long, dependable, maintenance-free, service life.

Oilgear engineering and equipment has solved innumerable "problem drives." Users of Oilgear *ANY-SPEED* Drive and Control Systems in the paper, marine, food, chemical, pharmaceutical, primary metals, metalworking, textile, rubber, and other industries — as well as the military . . . agree that — *"for the lowest-cost-per-year . . . it's OILGEAR!*

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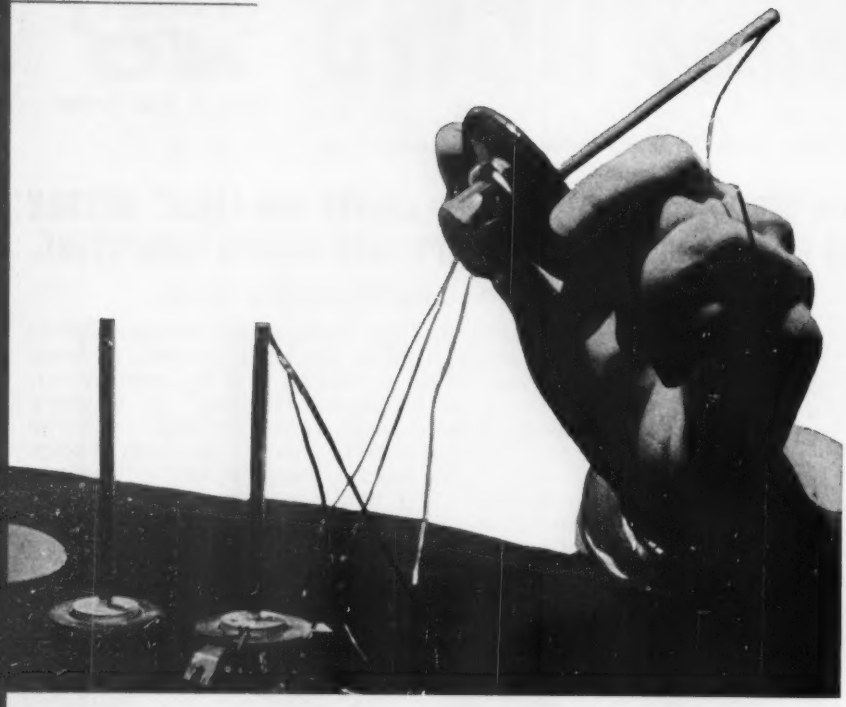
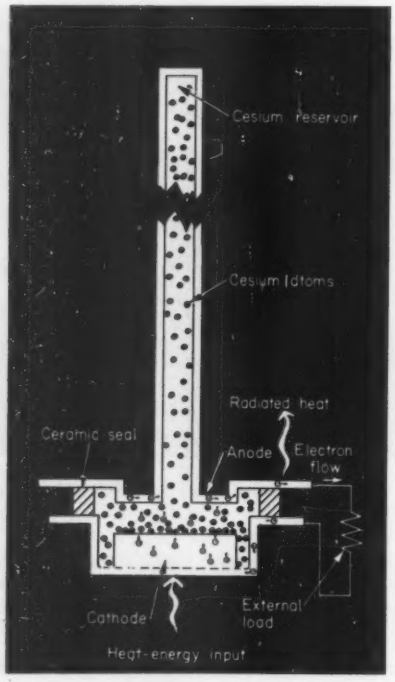


Thermionic Converter Runs on Everyday Fuels



Recent advances in materials technology and a new sealing technique are the developments that made the new thermionic converter feasible. According to GE, the device is especially attractive as a space-power system because it is rugged and needs no auxiliary cooling.

SCHENECTADY, N. Y.—A new thermionic converter may give other electric generators serious competition for small power-production jobs. Unlike previous thermionic units, it does not require the high temperatures that can only be produced by a nuclear reactor; solar collectors and fossil fuels furnish all the heat input necessary.

Developed by General Electric Co., Power Tube Dept., the converter operates at a cathode temperature of 2350 F—more than 1000 F below the usual design level. Yet, efficiency is as high (11 per cent) as in hotter thermionic units, and is nearly double that of thermoelectric generators. The device turns heat into electricity more efficiently at higher cathode temperatures (GE researchers have tested it to 3200 F), but the "cold" cathode optimizes reliability.

The present model delivers 10 watts at a power density of 2.4 w per sq cm. A sealed-off cesium vapor device, it has an integral radiator and reservoir. Heat losses from the anode (operating at about 1100 F) amount to 70-80 w, but from the reservoir (575 F), losses are negligible.

Survey Points Out Engineers Aren't Satisfied

Most Feel They Can Gain By Changing Jobs Often

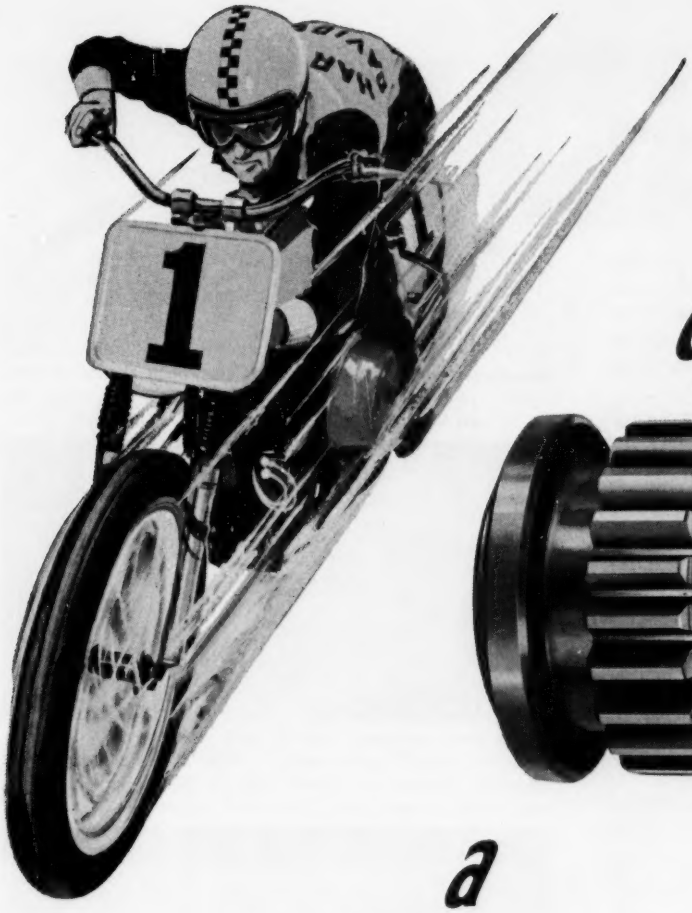
NEW YORK—One out of every four engineers is dissatisfied with his present job, according to a recent survey conducted by Deutsch & Shea Inc., manpower communications consultants. The study, *A New Look at Engineer Attitudes*, goes on to show that 82 per cent of the engineers feel there is much to gain by changing jobs—including increased earnings.

Engineers now have an underlying feeling of assurance: For the past ten years they have been living with the knowledge that there is no shortage of jobs. They know it is nearly always possible to move on if working conditions are bad.

Most engineers have made two or three job changes during the last decade, and have added considerably to their knowledge of conditions in industry. These job shifts, coupled with what has been learned from colleagues and from long exposure to recruiting efforts, have given the engineers a new sophistication. They believe they can better themselves on a new job, but they also know there is no Utopia around the corner.

Absence of advancement possibilities, lack of challenging work, and dissatisfaction with pay are the major reasons why engineers change jobs, according to the survey respondents. But while only 14 per cent of those interviewed concede that financial considerations partly motivated them to make a change, most agreed money was the major reason for their associates' moves.

During the last ten years, there has been a real change in the status of the engineer. He has grown aware of his importance, and a strong movement has sprung up to fit him "comfortably" into the industrial environment. Still, engineers remain a restless group that maintains a basic loyalty to the profession, rather than to the company. "There are no bad engineers, only bad companies." And this professional loyalty is one reflection of the engineer's intense, overriding interest in his work—it is from his work that he gains his greatest satisfaction as an employee.



Steel that gives cycles a stronger heart

Quick shifts and surges of power put terrific strain on the heart of a motor cycle transmission—the gears. To be sure the gears in all models including the racing models would have maximum strength, Harley-Davidson engineers came to Timken Company steel experts. They selected a special grade of Timken® fine alloy steel for the main shaft, countershaft and main drive gears. Result: Better performance—longer life. The Timken fine alloy steel used has the hardenability that assures maximum core hardness, along with the ductility needed to absorb shock and impact loads. And it has the strength to keep gears meshing more smoothly, more accurately, and longer.

What's more, because we target our processing to your end use, your products will have superior, uniform quality when you use Timken fine alloy steel. Let us show you how. Call or write: The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

TIMKEN®
Fine Alloy STEEL

Timken Alloy Steel and Seamless Steel Tubing Are Available from Steel Service Centers in 44 Cities in the United States

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Hot Rolling Welds Corrugated Sandwich

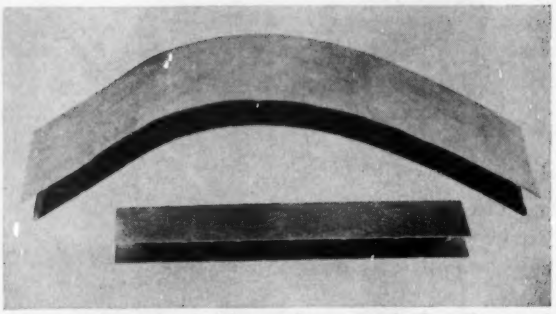
Wedges Block Buckling When Panels Are Shaped

COLUMBUS, OHIO—Already credited with a price edge over honeycomb, all-metal corrugated sandwiches can now be produced more easily and less expensively than ever before by a new fabrication technique that requires no jigging. Sound core-to-cover bonds and excellent rigidity are obtained.

Developed by Battelle Memorial Institute for Douglas Aircraft Co., the production method involves hot rolling the sandwich in the direction parallel to the corrugations. During the rolling operation, the peaks in the corrugated metal become pressure welded to the metal face sheets, and the cross section decreases in thickness by as much as 60 per cent, providing the desired corrugation shape. The technique, called roll-welding, can also be used to produce sandwiches with vertically ribbed cores. The only limitation is that the core has to be unidirectional.

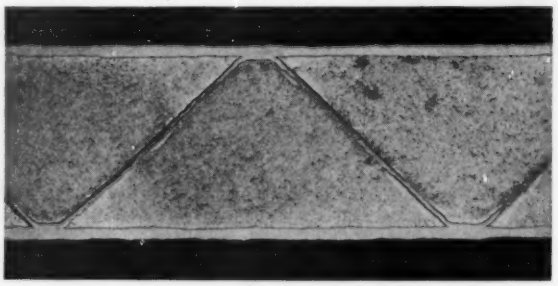
V-shaped inserts of chemically soluble, deformation-resistant metal (such as copper or iron) are the key to fabrication of the sandwich. Accordion-pleated sheets of metal are woven over and under the inserts, and face sheets are added. Once the panels are hot rolled, they can be formed to their final shapes (including hemispherical) without buckling the cores. After forming is completed, the inserts are leached out of the structures with a chemical reagent.

Size of sandwich panels is limited only by rolling-mill capacity. Quarter-inch panels measuring 36 by 72 in. were the largest produced by Battelle, but bigger ones are feasible. To date, roll-welded structures have been formed from 2014 aluminum alloy, B-120 VCA titanium, unalloyed A-55 titanium, steel, molybdenum, and Inconel.



Corrugated-core sandwich panels approach the all-around rigidity of honeycomb. Simple to manufacture, they can be formed into a variety of shapes after assembly.

Metal filler wedges, inserted before hot rolling (above), keep the core from crushing. After the pressure-welded structure (below) is formed into its final shape, wedges are leached away with a suitable reagent.



Largest Exhibit Scheduled for Design Show

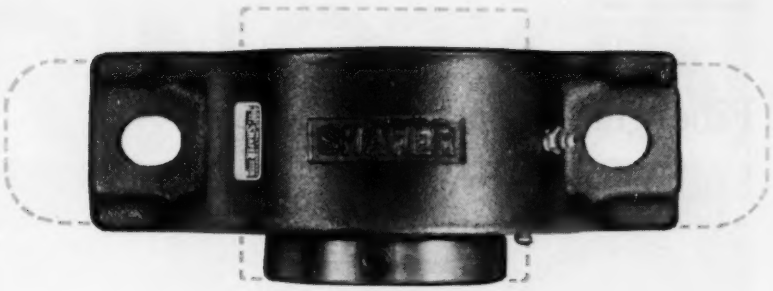
THE 1961 Design Engineering Show and Conference, scheduled for May 22-25 in Detroit, will present the largest exhibit of engineering products, materials, and services in its history. The Conference, held during the morning hours, will also be substantially enlarged, and will be broken up into separate concurrent sessions after the first day.

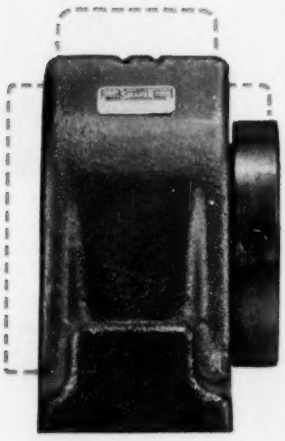
Newly opened Cobo Hall, with its unusual construction and advanced design, will permit five acres of exhibits in an area that is virtually free of columns and pillars. Modern lighting will deliver 150 candle power at reading-level height to further enhance the viewing of displays and equipment.

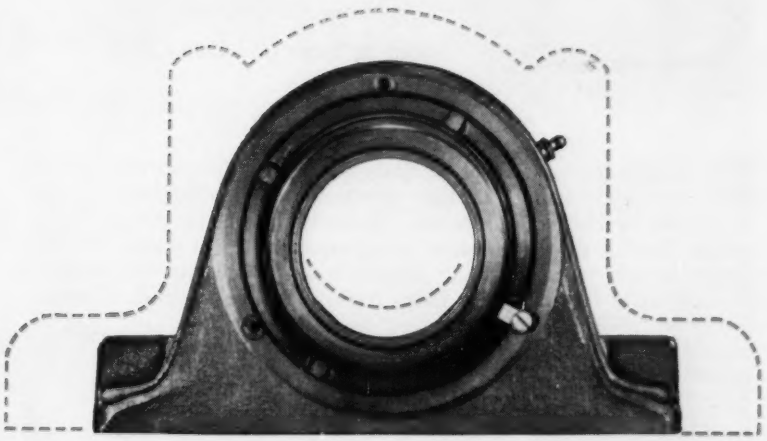
Almost every large manufacturing company in the country—over 400 in all—will exhibit during the four-day show. Hundreds of qualified application engineers will man the booths, anxious to go over new plans and proposals with the visitors. Engineers from all over the U. S. will attend, and a record number of Canadian engineers is expected because of the Detroit location. Displays will exceed $10 million in value, with over 15,000 products being shown.

Theme for the Conference will be "Designing for Today's Competitive Market." On the first day, spokesmen for the automobile industry will describe how the public's taste in cars is measured and satisfied, and how automotive components are designed at minimum cost.

On succeeding days, specific design problems will be considered. The simultaneous Tuesday sessions are typical of the subject range covered: 1. Manufacturing—Key to Saving. 2. Automatic Equipment Speeds Production. 3. Glass and Ceramics Offer New Design Possibilities. 4. High-Strength Steel—Impact of Recent Development.







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It's easier to install, too, for it's delivered completely assembled, adjusted, lubricated and sealed—saving installation time, assuring proper adjustment and dirt-free lubrication.

Shafer-Rex Roller Bearing units meet all the critical requirements for longest bearing life. They help your equipment survive even those unexpected conditions that so often cut bearing life short; for example: severe overloads, shock loads, thrust loads, combined loads, and changing misalignment.

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For full information, write CHAIN Belt Company, 4643 W. Greenfield Ave., Milwaukee 1, Wis. In Canada: Rex Chainbelt (Canada) Ltd., Toronto and Montreal.

SHAFER® REX®
SELF-ALIGNING ROLLER BEARINGS

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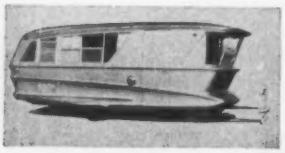
Fiberglass-Sandwich Shells Lighten the Travel Trailer

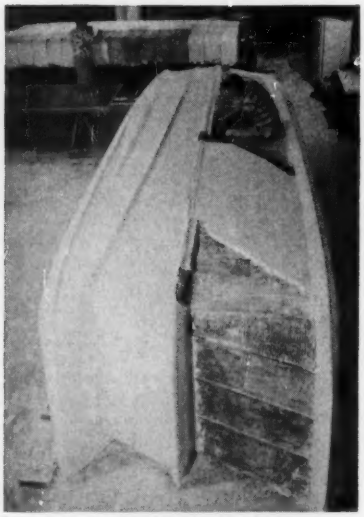


Paper-Honeycomb Cores Separate Inner and Outer Skins

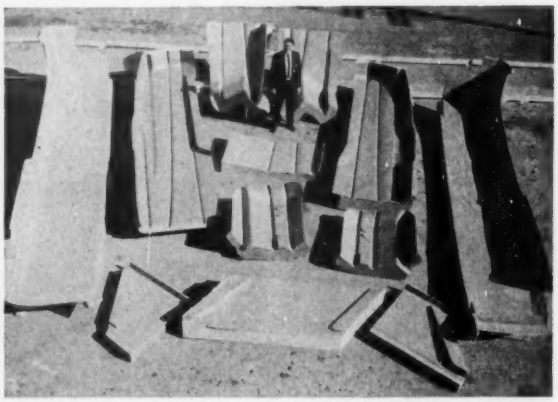
SHEATHED inside and out in fiberglass, a new travel trailer seems likely to convert many armchair sportsmen into the outdoor variety. Developed by Holiday House Inc., Medford, Oregon, the strong, lightweight "mobile motel" contains luxury equipment that would add excessive pounds to conventional aluminum and wood vacation trailers. In contrast to the mammoth house trailers that are designed as semi-stationary residences, travel trailers are small, highly maneuverable vacation homes that can be easily pulled around back roads of the country.

Walls and ceiling are contour molded 1-in. skins, separated by three-ply paper cores of honeycomb. The panels are first sandwiched together and bonded to the honeycomb, then bonded to each other, giving the trailer a one-piece stressed skin. Both interior and exterior surfaces consist of double-laminated fiberglass in polyester resin. When one of the reinforced ¾-in. cores was cut up for test, it withstood more than 100 psi in compression and flex, and 11,000 psi in edgewise compression.

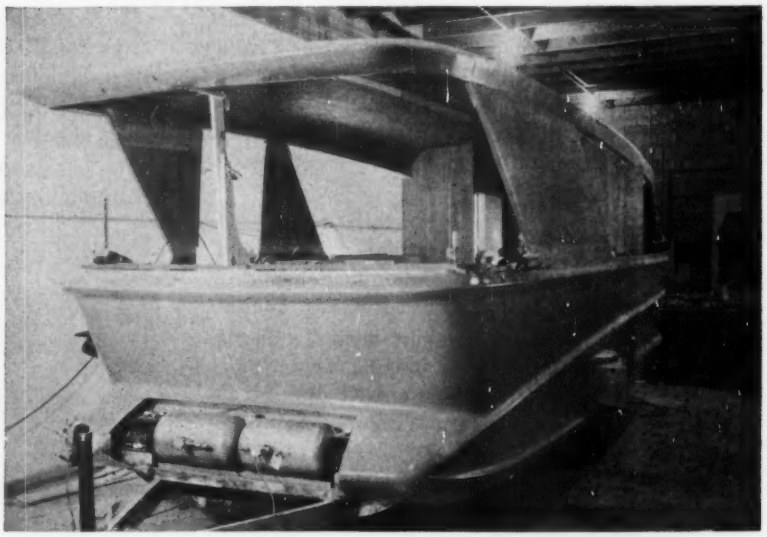
Not yet in production, the fiberglass trailer was first conceived last August. Its design was formulated, molds were built, and a prototype was produced within six months. The trailer is now undergoing endurance testing in the field and should be on the market in late summer or early fall.



Aluminum templets were laid out in the shape of the trailer, and were covered by plaster patterns (above). More than 6000 lb of plaster went into the mold patterns.

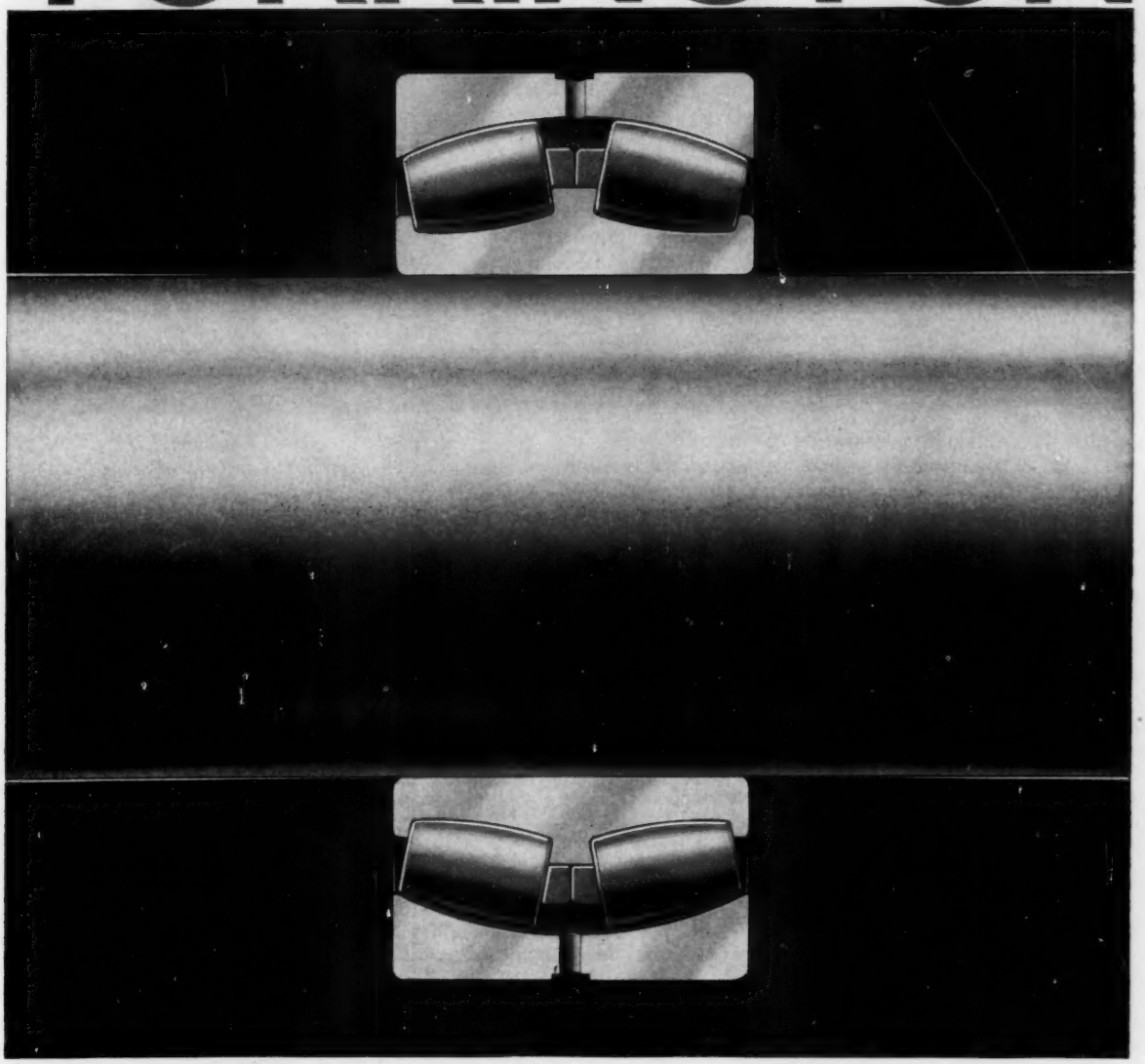


Twelve molds are required for the body of the trailer. Roof molds (extreme right and left) measure 24 ft long by almost 5 ft wide. Each requires 166 sq yd of glass roving and weighs nearly 600 lb.



Advantages claimed for the fiberglass vacation trailer over conventional models include light weight (15 oz per sq ft of surface area), leak-proof construction, good heat insulation, long maintenance-free life, and high resistance to damage from impact or from the elements. Trailers now coming off the production line are being sent to different parts of the country for testing under the most adverse conditions.

TORRINGTON



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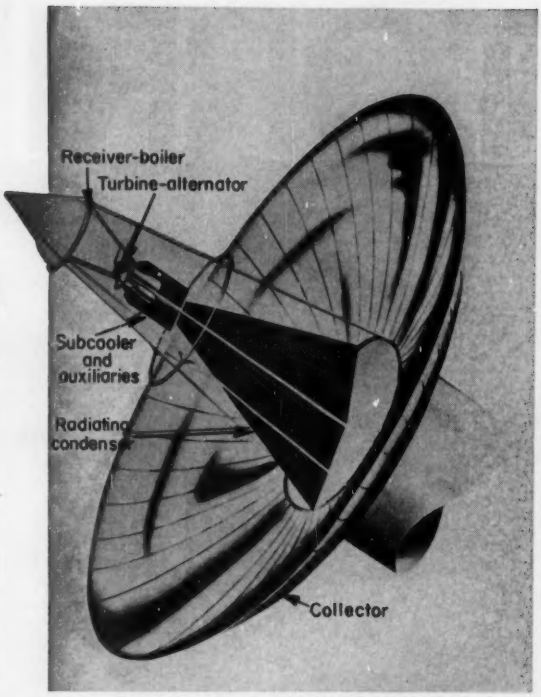
Circle 210 on Page 19

Sunflower in Space:

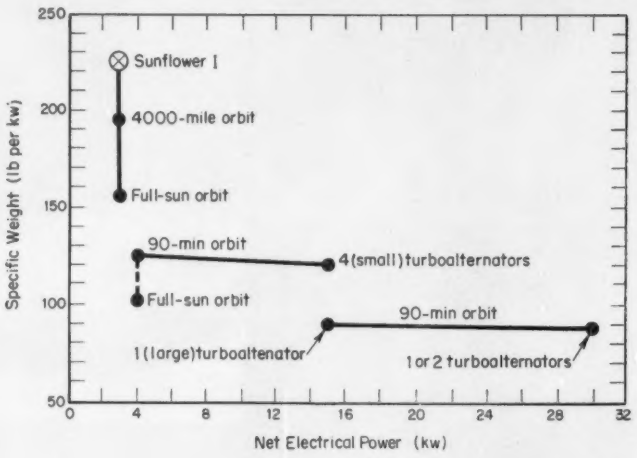
Power from Proved Hardware



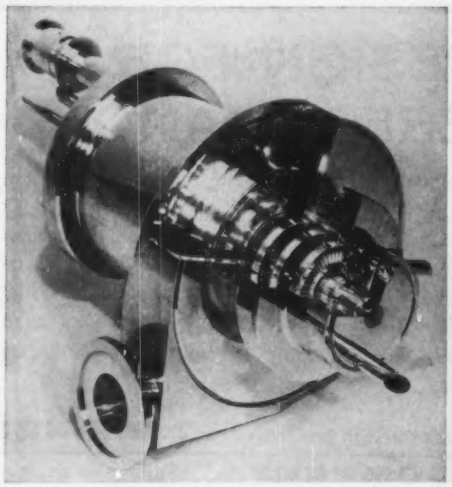
CLEVELAND—Auxiliary-power systems based on the Sunflower concept (hinged "petals" unfolding to form a parabolic solar collector) may be the most practical first-generation method of producing electricity in space. C. J. Daye, senior research engineer, Thompson Ramo Wooldridge Inc., Tapco Group, told the recent ASME Aviation Conference that Sunflower systems have a big advantage: They involve existing hardware and are based on state-of-the-art knowledge.

Designed around a Rankine-cycle turbine-alternator package that uses mercury as the working fluid, Sunflower systems could fill the gap until extremely advanced electric generators are ready. Prototypes have been under test for over two years, and have operated for more than 2500 hours at 1200 F. Although Sunflower I is designed to produce only 3 kw, solar-conversion systems seem particularly attractive for power outputs up to 30 kw. They should remain competitive with other systems for many years.

Growth possibilities for Sunflower stem from several avenues of approach to upgrading the systems. Power output and specific weight (lb per kw) of the present system can be improved by component development; multiple turbine-alternator packages and more efficient power-conversion units can be designed for increased power production. In addition, the reflector, energy-storage system (drained when the reflector is in shadow), and boiler used to drive the alternator all can be tailored for particular orbits, providing a family of space-power systems that is based on applying proven techniques to existing machinery.



Present Sunflower system is excessively heavy because it must travel in an orbit ranging from 300 (90-min period) to 20,000 nautical-miles out in space. If tailored to a less eccentric path (4000-mile orbit, above right), or designed for full-sunlight operation, weight could be decreased substantially. A more favorable specific weight can also be obtained by further component development and by designing multiple-turboalternator systems (charted for the 90-min orbit case). Both the turboalternator (near right) and the collector (10-ft model, far right) can be sized for specific orbits and applications. Two major factors are involved in matching components and providing the optimum specific weight for a mission: Time required for the satellite to pass through the earth's shadow, and percentage of time spent in shadow.



Supply of Engineers Suffers Slight Rise

WASHINGTON—The job market for engineers appeared somewhat weaker at the end of 1960 than it did in midyear, reports the U. S. Dept. of Labor in its *Current Labor Market Conditions in Engineering, Scientific, and Technical Occupations*. The supply of engineers, indicated by the number of active job applications in 30 major labor-market areas, increased 1.7 per cent, mostly in civil, industrial, and mechanical specialties.

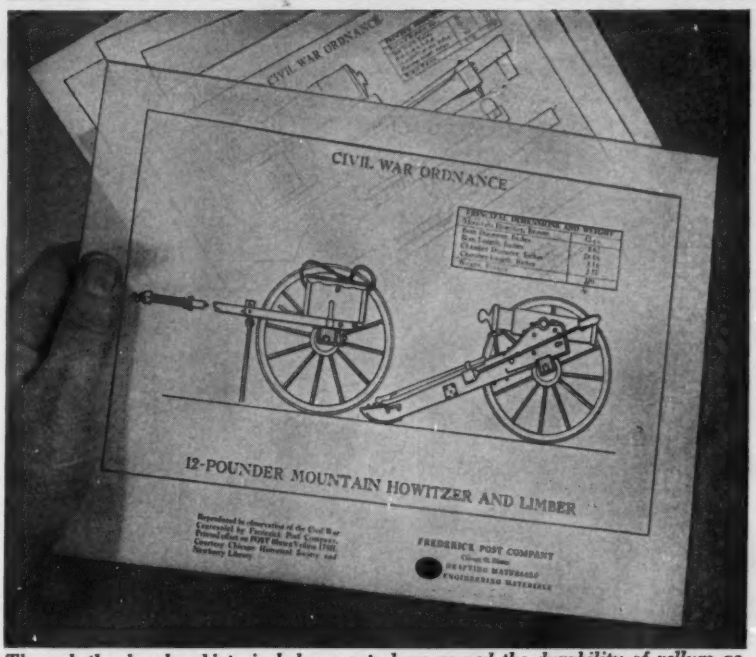
Chicago recorded the largest half-year rise in job applications (130 more in November than in May). Layoffs have been heavy in the electrical-machinery industry and in tool-design firms. Companies have been reducing employment by not replacing engineers who quit or retire.

New York, Milwaukee, and Washington also had 50 to 100 more applicants in November. In contrast, the Los Angeles-Long Beach area reports almost 400 fewer engineering-job seekers (attributed to a rise in defense spending), and Dallas also had more than 50 fewer applicants (attributed to out-of-the area recruiting).

Unfilled openings for engineers remained at about the same level, but demands in certain specialties—including civil, mechanical, and aeronautical—rose significantly. The increase, confined largely to the Pacific Coast, was counterbalanced by declines in a number of other categories—notably electrical and industrial. Milwaukee reports less need for electricals; Denver claims cutbacks have leveled off employment in the aircraft-parts industry. Fewer openings for industrial engineers are reported by the Boston, St. Louis, Denver, and Seattle offices of the Labor Dept.

While demands for electrical engineers have been reduced, this category still accounts for the largest proportion of unfilled needs. About 40 per cent of the engineering openings were in this group last November, as compared to 50 per cent in May. Many areas continue to report urgent demands for electronic engineers, although indicating that employer requirements relating to specialized experience have tightened.

DRAFTING TRENDS



Through the decades, historical documents have proved the durability of vellum as indicated by the facsimiles of Civil War engineering drawings above, reproduced on POST *Blutex Tracing Vellum.*

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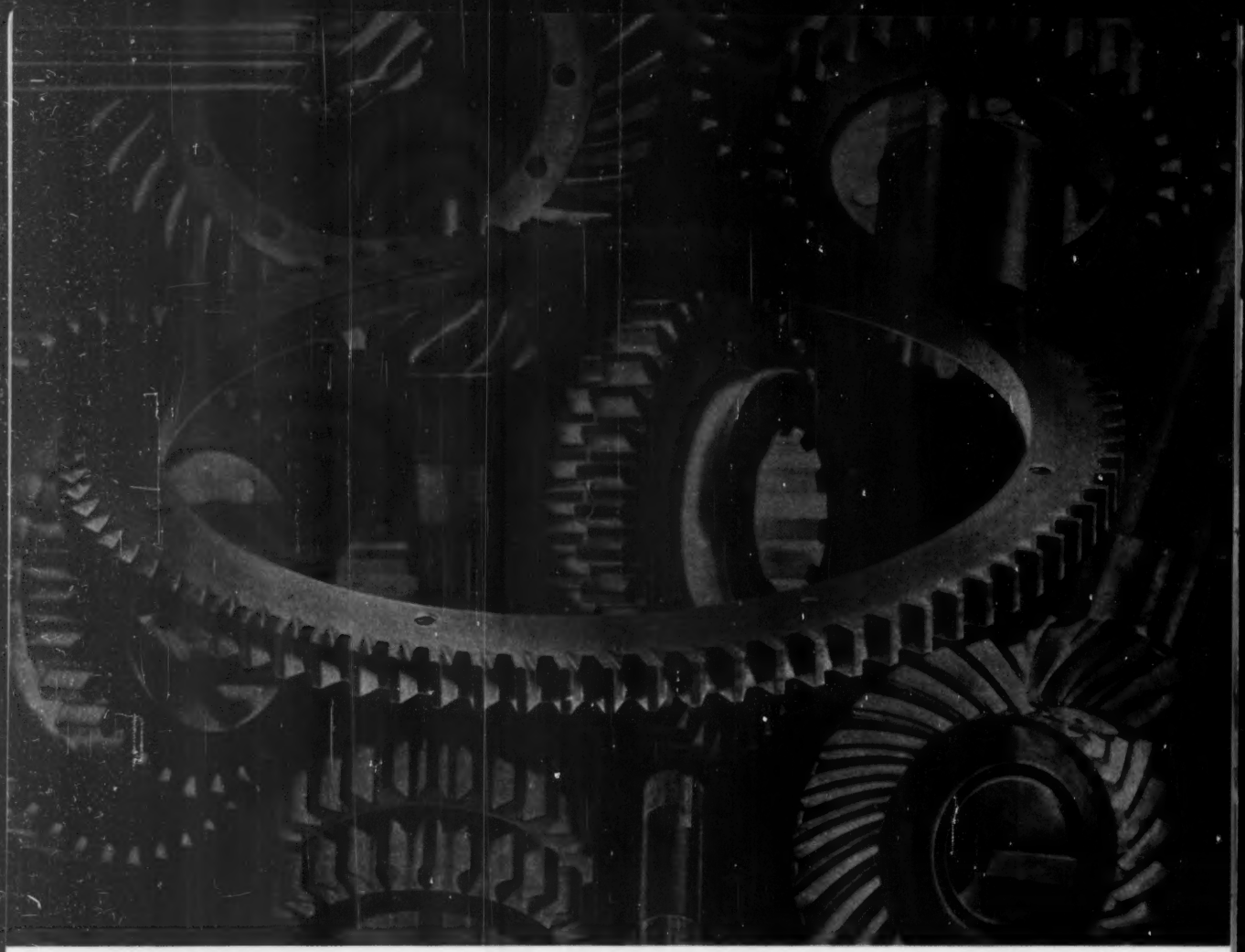

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- Information about new parts, materials
- Design data on advertised products
- Extra copies of editorial articles

HELPFUL LITERATURE

Descriptions of items start on Page 164. Starred items are from April 13 issue.

Electrical, Electronic

502 Adjustable-Speed Drives. 88 pp. Reliance Electric & Engineering Co.

503 Stock Transformers. 34 pp. Chicago Standard Transformer Corp.

506 Metallized Mylar Capacitors. 4 pp. Potter Co.

507 Worm-Gear Motors. 6 pp. U. S. Electric Motors Inc.

509 Piezoelectric Devices. 16 pp. Clevite Electronic Components.

510 Miniature Electric Eyes. 22 pp. Photomation Inc.

515 Servo Motors. 14 pp. Holtzer-Cabot Motor Div., National Pneumatic Co. Inc.

516 Color-Measurement Equipment. Two bulletins, 4 pp. each. Colorimetry Div., Allied Research Associates Inc.

519 Precision Potentiometers. 6 pp. Potentiometer Div., Daystrom Inc.

523 Teflon Terminals. 4 pp. Sealectro Corp.

525 In-Line Readouts. 16 pp. Electronic Tube Div., Burroughs Corp.

529 Transistorized Power Supplies. 4 pp. Invar Electronics Corp.

531 Terminal Insulators. 24 pp. Coors Porcelain Co.

577 Silicon Rectifiers.* More than 350 JEDEC types listed. Bulletin 300, 6 pp. Semiconductor Div., Syntron Co.

578 Adjustable-Speed Drives.* For pumping applications. Bulletin 5560, 8 pp. Westinghouse Electric Corp.

579 High-Speed Computing System.* Basic, medium, and large systems. Bulletin QC-020-R110, 18 pp. Bendix Computer Div., Bendix Corp.

580 Temperature Controls.* New 500-line controllers and indicators. Brochure MC-195, 8 pp. Fenwal Inc.

581 Connector Protectors.* For miniature electronic pin connectors. Bulletin P-6012, 4 pp. Plastic Div., S. S. White Industrial Div.

582 Transistor Transformers.* Miniature units, designated Buds and Mites. Catalog Supplement 2, 4 pp. Decco Inc.

583 Miniature Panel Meters.* Includes 1 and 1½-in. units. 4 pp. International Instruments Inc.

584 Liquid-Level Controls.* Describes electronic floatless units. Bulletin 334, 4 pp. B/W Controller Corp.

585 Silicon Mesa Transistors.* For medium-power audio uses. ECG-538, ECG-528, 6 pp. each. Semiconductor Products Dept., General Electric Co.

586 Size-8 Components.* For aircraft, missile servo systems. 12 pp. Kearfott Div., General Precision Inc.

Hydraulic, Pneumatic

512 Valve Selector Chart. 4 pp. J. D. Gould Co.

521 Pilot-Operated Valve. 4 pp. Airmatic Valve Inc.

524 Venturi Valves. 6 pp. Fox Valve Development Co. Inc.

526 Shaft Seals. 6 pp. Del Mfg. Co., Div., Arrowhead & Puritas Waters Inc.

532 Liquid Spring Shocks. 12 pp. Taylor Devices Inc.

587 Aircraft Hydraulic Filters.* Meet Specification MIL-F-8815. Bulletin A7, 8pp. Pall Corp.

588 Centrifugal Pumps.* Single-stage units are detailed. Bulletin 725.8, 16 pp. Goulds Pumps Inc.

589 Metallic Static Face Seals.* For missiles and aircraft use. 4 pp. Haskel Seals Div., Haskel Engineering & Supply Co.

590 Metallic Seal.* Pneuflex seal for high-pressure use. 8 pp. Del Mfg. Div., Arrowhead & Puritas Waters Inc.

591 Centrifugal Pumps.* Provide capacities to 140 gpm. Catalog 5-7253, 4 pp. National Carbon Co., Div., Union Carbide Corp.

592 Turbine Flowmeters.* Two new models are detailed. Bulletins 10C1505; 51-2860. 14 pp. total. Fischer & Porter Co.

593 Hose Assemblies.* Quick guide to numbers and types. Bulletin IEB-53, 4 pp. Aeroquip Corp.

594 Pump-Motor.* Polyphase and single-phase types. Bulletin 1455, 4 p. Century Electric Co.

595 Sight-Flow Indicators.* Flapper and rotory types. Bulletin 18W, 4 pp. Schutte & Koerting Co.

Mechanical Equipment

511 Ball Bearings. 4 pp. Landis & Gyr Inc.

517 Chain Selection Chart. Foote Bros. Gear & Machine Corp.

518 Gears and Related Parts. 4 pp. Instru-Lec Corp.

528 Stock Sprockets. 8 pp. Dayton Rogers Mfg. Co.

596 Stamped Gears.* Covers specifications and formulas. Catalog 6011, 16 pp. Winzeler Mfg. & Tool Co.

597 Self-Aligning Bearings.* Monoball self-aligning and rod-end units. Catalog 551, 56 pp. Southwest Products Co.

598 Adjustable-Speed Belts.* Interchange guide, rubber and wood-block belts. 8 pp. Manheim Mfg. & Belting Co.

599 Adjustable-Speed Belts.* For industrial applications; includes change-over guide. Catalog 61-C, 14 pp. Lovejoy Flexible Coupling Co.

600 Chain Drives.* Data based on new ARSCM horsepower ratings. Catalog PTCB, 125 pp. Dept. MJ, Foote Bros. Gear & Machine Corp.

601 Miniature Bearings.* Radial, radial flanged, pivot, roller, special types. Catalog 3E, 16 pp. Landis & Gyr Inc.

602 Power-Transmission Equipment.* Stock parts descriptions, data. Catalog GC-101-F, 24 pp. Browning Mfg. Co.

Assembly Components

520 High-Strength Bolt. 4 pp. Standard Pressed Steel Co.

603 Spring-Tension Fasteners.* Customized designs, case-history examples. 4 pp. Associated Spring Corp.

604 Retaining Rings.* Prestacked internal and external units. Catalogs 30, 31, 4 pp. each. Industrial Retaining Ring Co.

605 One-Piece Metal Enclosures.* Made in any configuration. Sheet F10412, 2 pp. Barber-Colman Co.

606 Push-Type Insert.* For use in plastics after molding. Bulletin 777, 2 pp. Heli-Coil Corp.

607 Corrosion Guide.* For fasteners, covers seven basic types of corrosion. 24 pp. H. M. Harper Co.

608 Torque-Tension Manual.* For thin and standard-height stop nuts. Manual 6101, 18 pp. Elastic Stop Nut Corp. of America.

609 Industrial Fasteners.* Unbrako, Flexloc, Sel-Lok, Hallowell types. Form 2449, 8 pp. Box 102, Standard Pressed Steel Co.

610 Timing Screws.* Custom units, engineering principles. Brochure STE-596, 4 pp. Arthur Colton Co.

611 Self-Locking Cap Screw.* Design and principle of locking Kapscrew. 4 pp. Dept. KKL-262, Klincher Kapscrew Inc.

Manufactoring Processes, Parts

612 Welded Steel Designing.* Design of thin, flat structures. Study 1204.3, 4 pp. Lincoln Electric Co.

Materials

501 Silicone Data. 16 pp. Silicones Div., Union Carbide Corp.

504 Polyester Resins. 12 pp. Plastics & Resins Div., American Cyanamid Co.

505 Industrial Ceramics. 20 pp. Saxonburg Ceramics Inc.

508 Laminated Plastics. 8 pp. Taylor Fibre Co.

513 Aluminum Selection. 6 pp. Fairmont Aluminum Co.

514 Glass, Glass-Ceramics. 68 pp. Corning Glass Works.

527 Nylon Extrusions. 8 pp. Danielson Mfg. Co.

613 Advanced Materials.* Data on 12 new products. 8 pp. Carborundum Co.

614 Thermoplastics Properties.* Mechanical and electrical properties of five materials. 4 pp. A. L. Hyde Co.

615 Potting Compound.* LTV-602 clear silicone compound described. Bulletin CDS-280, 4 pp. Silicone Products Dept., General Electric Co.

616 Nylon Stock Shapes.* New MC nylon properties and applications. Bulletin MC-2, 4 pp. Polymer Corp.

617 Rulon, Teflon Parts.* Electrical, physical, mechanical, chemical properties. Brochure 9572, 4 pp. Plastics Div., Dixon Corp.

HELPFUL LITERATURE (Cont.)

618 Expanded-Foam Plastic.* Pac-Trim, for packaging, cushioning, and protecting parts. Catalog 3, 7 pp. Pac-Tron Inc.

Engineering Dept. Equipment

522 Drafting Film. 8 pp. Keuffel & Esser Co.

530 Drafting Aids. 32 pp. Hamilton Mfg. Co.

619 Drafting Film.* Ark-A-Tex data in sample folder. Arkwright Finishing Div., Arkwright-Interlaken Inc.

620 Drafting Aids.* Precut, pressure-sensitive shapes for drafting use. Bulletin P-30A, 6 pp. By-Buk Co.

621 Laboratory Oscilloscopes.* Full data on eight complete units. 20 pp. Tektronix Inc.

622 Bolt-Strain Gage.* Strainsert bolt functions described. Bulletin 361, 4 pp. Strainsert Co.

623 Torque Measurements.* Measuring torque, speed of motors, gear trains, etc. 12 pp. Power Instruments Inc.

Circle the item number for information on products advertised or described, literature offered, and copies of editorial articles.

NEW PARTS, MATERIALS, ENGINEERING EQUIPMENT

Descriptions start on Page 174.

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537 DC torque motor has completely encapsulated armature. Curvin Development Co.

538 Silicon solar cells are gridded for increased efficiency. International Rectifier Corp.

547 Silicon rectifiers for 1 ma continuous duty. Electronic Devices Inc.

548 Encapsulated meters in 545U and smaller frame sizes. Louis Allis Co.

549 Elapsed-time indicator registers to 99999.9. General Time Corp.

553 Motor reducers in ratings from ½ through 50 hp. Reuland Electric Co.

557 Pushbutton switch takes eight indicator lamps in 4 to 48-v sizes. Sylvania Electric Products Inc.

559 Edgewise meters are for severe environments. Precision Meter Div., Minneapolis-Honeywell Regulator Co.

560 Trimming potentiometer is ⅜ in. square, 0.140 in. thick. Potentiometer Div., Daystrom Inc.

561 Limit switch has built-in neon indicator lamp. Micro Switch Div., Minneapolis-Honeywell Regulator Co.

563 Fractional-horsepower motors are rated ¼ to ¾ hp. General Electric Co.

566 Motorized speed drive in sizes from 1/3 to 15 hp. Cleveland Worm & Gear Div., Eaton Mfg. Co.

567 Mercury-wetted relay provides high sensitivity and speed. C. P. Clare & Co.

Hydraulic, Pneumatic

533 Swivel fittings provide 360-deg rotation. Dumont Engineering Co.

534 Static spring seal handles temperatures from −320 to +1500 F. Hydrodyne Corp.

543 Hydraulic cylinders for low-pressure use. Milwaukee Cylinder Co.

544 Solenoid valves for use in hazardous locations. Skinner Electric Valve Div., Skinner Precision Industries Inc.

552 Metal swivel joint operates at temperatures from −425 to +1500 F. Ssalol Inc.

558 Dual-purpose valve for pneumatic service is self-contained. Modernair Corp.

562 Pressure regulator has micrometer adjustments. Circle Seal Products Co. Inc.

570 Tandem cylinders for maximum 200 psi pressure. Tom Thumb Div., Pneumatic-Hydraulic Development Co.

571 Extruded plastic tubing in sizes to 3 in. OD. Petro Plastics Co.

Mechanical Equipment

555 Midget bearings are permanently lubricated and self-aligning. Randall Graphite Bearings Inc.

556 V-belt pulleys have cam-control design. Lovejoy Flexible Coupling Co.

564 Stock gears are 20-deg-pressure-angle units. Morse Chain Co.

Assembly Components

536 Electric panel fastener is spring-ejected. Southco Div., South Chester Corp.

540 Wire markers are self-adhering and self-laminating. Westline Products Div., Western Lithograph Co.

541 Threaded insert provides brass threads in molded plastic. Phelps Mfg. Div., Heli-Coil Corp..

542 Turns-counting dial for shaft-controlled units of ten turns or less. Borg Equipment Div., Amphenol-Borg Electronics Corp.

545 Self-adhesive nameplates of aluminum foil or polyvinyl chloride. W. H. Brady Co.

546 Self-locking fastener provides nut anchor in sheet metal. Penn Engineering & Mfg. Corp.

550 Self-sealing screws seal internal and external pressures over 500 psi. A. P. M. Corp.

551 Cable clamp for use on electronic equipment. Vemaline Products Co.

554 Lock nut for 1400 F applications. Standard Pressed Steel Co.

565 Spring-loaded latch operates in removable panels and access doors. Monadnock Mills.

569 Rectangular fasteners incorporate fast-action key nut for securing. TA Mfg. Corp.

Materials

535 Plastic-coated material is pressure-sensitive and decorative. Avery Label Co.

539 Silicone rubber provides strong bond to ferrous-containing metals. Silicone Products Dept., General Electric Co.

568 Neoprene contact adhesive gives strong, resilient bonds. Industrial Div., Armstrong Cork Co.

Engineering Dept. Equipment

572 Combination drafting aid consists of slide rule and drawing pencil. Alvin & Co. Inc.

573 Strain gage incorporates built-in computer. Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp.

574 Gear layout kits in 48, 64, and 96 diametral pitch. Advanced Designs Inc.

575 True compression accelerometer has range of 0.02 to 40,000 g. Columbia Research Laboratories.

576 Strip-chart recorder is accurate within ±1 per cent. Atkins Technical Inc.

EDITORIAL ARTICLES

Single copies of the following articles are available as long as the supply lasts. Starred items are from previous issues. See Page 210 for other available reprints. Editorial content of MACHINE DESIGN is indexed in the Applied Science & Technology Index and the Engineering Index, both available in libraries. Microfilm copies are available from University Microfilms, 313 N. First St., Ann Arbor, Mich.

9-1 More Sports Cars from Europe. Glamour, speed, mechanical sophistication offered.

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9-3 Technical Literature. Techniques for weeding out material with limited value.

9-4 Preventing Fatigue Failures—Part 1. Factors affecting fatigue life in a machine part or structure.

9-5 Natural Frequencies of Multiple-Mass Systems. Computing natural frequencies; solution for torsional frequencies of complex interconnected systems.

9-6 Chemically Milled Structures. Advantages and disadvantages of chemical milling; design of chemically milled parts.

9-7 High-Reduction Hypoids. Types and applications; design of sets for ratios from 10:1 to 120:1.

9-8 Self-Checking Interpolation. Finding an intermediate value from values already tabulated for a nonlinear function.

9-9 Reliability Predictions in Design (Abstract). Pros and cons of predicting performance under given conditions of environment and time.

8-1 Managerial Planning.* Plan-making methods for engineering managers.

8-2 Pressure Regulators.* Basic principles and types; selection and application.

8-3 Elastic-Body Mechanics.* New principles in using elastic properties of materials to solve design problems.

8-5 Positioning Gear Shafts.* Axial shaft-location methods for minimizing system backlash and gear-tooth wear.

8-7 Designing Cam Profiles.* Calculation of polynomial cam curves to fit mixed conditions of displacement, velocity, and acceleration.

7-1 From Engineer to Manager.* Six major routes to management.

7-5 Helical Spring Design.* A direct design procedure that eliminates trial and error.

7-6 Internal-Combustion Engines.* Factors in selecting engines up to 60 hp in size.

7-7 Tees in Bending.* Design curves for finding properties of tees and channels.

6-1 Engineering or Research.* Effect of company size on emphasis placed on engineering or research.

6-2 Conical-Disc Springs.* Designing for specific characteristics in minimum space.

6-3 Self-Sealing Couplings.* How to select air and hydraulic types for instant connection and disconnection without fluid loss.

6-8 Variable-Section Beams.* Calculating slopes and deflections when material is uniform but bending moment and moment of inertia vary.

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EDITORIAL ARTICLES

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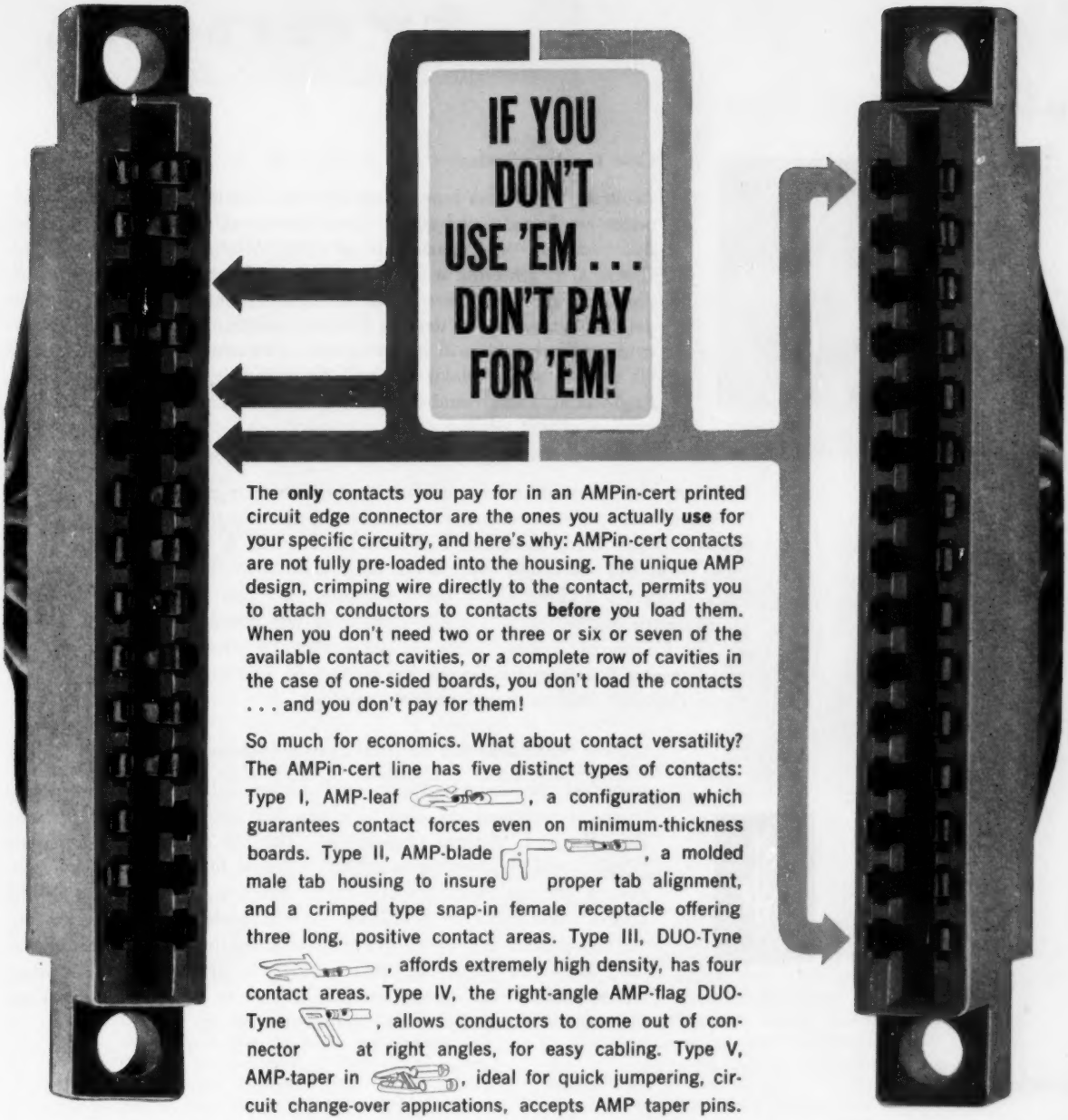

IF YOU DON'T USE 'EM . . . DON'T PAY FOR 'EM!

The **only** contacts you pay for in an AMPin-cert printed circuit edge connector are the ones you actually **use** for your specific circuitry, and here's why: AMPin-cert contacts are not fully pre-loaded into the housing. The unique AMP design, crimping wire directly to the contact, permits you to attach conductors to contacts **before** you load them. When you don't need two or three or six or seven of the available contact cavities, or a complete row of cavities in the case of one-sided boards, you don't load the contacts . . . and you don't pay for them!

So much for economics. What about contact versatility? The AMPin-cert line has five distinct types of contacts: Type I, AMP-leaf , a configuration which guarantees contact forces even on minimum-thickness boards. Type II, AMP-blade , a molded male tab housing to insure proper tab alignment, and a crimped type snap-in female receptacle offering three long, positive contact areas. Type III, DUO-Tyne , affords extremely high density, has four contact areas. Type IV, the right-angle AMP-flag DUO-Tyne , allows conductors to come out of connector at right angles, for easy cabling. Type V, AMP-taper in , ideal for quick jumpering, circuit change-over applications, accepts AMP taper pins.

Quality? AMPin-cert is quality, in the contacts and the housings:

- Contacts are phosphor bronze, gold over nickel plating
- Contacts accept single, multiple leads, and "snap-in" the housing without insertion tools
- Contacts are recessed in housing—no post insulation required
- AMPin-cert connectors will accept one-sided and two-sided boards

Ask us for the full AMPin-cert printed circuit connector story.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

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Circle 213 on Page 19

trends

engineering/personal

Case for Integration

Arbitrary boundaries long drawn between traditional engineering disciplines are being wiped out at Case Institute of Technology. Effective this summer, the departments of Civil, Mechanical, Electrical, and Chemical Engineering will become a single Engineering Division. Announcing the integration, T. Keith Glennan emphasized that, "for the present," no change in degrees offered is contemplated—i.e., B.S. degrees in designated fields will be continued. The new division, consisting of 40 men of professorial rank, will be administered in two groups: 1. Engineering Design and Systems. 2. Engineering Science.

Recruiters Flunk Interview Feedback

Well into the "wooing" season, graduating engineers are painting uncomplimentary portraits of many recruiters. Collecting the collegian consensus, Ben Britt, Industrial Relations Director, M & T Co., says these lackluster recruiting types have been identified: 1. The Yes Man (discovers nothing about the applicant). 2. The Interrogator (third-degree questioning). 3. The Busy Man (no questions at all). 4. The Columnist (gossipy probes of the applicant's private life). 5. The Repeater (rehashes the application form). 6. The Big-Time Operator (lavishly displays encyclopedic knowledge).

Higher Standards for Federal Status Seekers

Improved professional status—and higher salaries—for government technical personnel are aims of a new bill introduced in Congress by Rep. Victor L. Anfuso (Brooklyn). The bill establishes a ten-grade "Professional Engineering-Scientific" schedule for professional-level engineers, physical scientists and mathematicians, with salaries starting at $6400 and going up to $20,000. While provisions are made for converting present employees to the new schedule, Anfuso recommends that, after two years, no person should be granted the PES rating unless he holds an appropriate B.S. degree, is a licensed professional engineer, or is certified as an engineer-in-training.

materials

POOR CONTROL OF SURFACE CARBON can lead to "insidious" fatigue failure in high-strength bolts, says Standard Pressed Steel Co. in a special report, "Hidden Cause of Bolt Failure." Testing socket-head cap screws, SPS found that surface hardness optimized at Rc 43 (0.40 carbon), gave a fatigue life of 100,000 cycles. Life fell to 47,000 cycles with slight decarb (0.30), or slight carburization (0.50).

TWENTY PER CENT LIGHTER than conventional magnesium, magnesium-lithium alloys appear to be the lightest metals suitable for space structures, says Battelle Memorial Institute. Although strength isn't high (about 25,000 psi), ratio of modulus to density is greater than for magnesium, aluminum, or steel. Battelle is studying Mg-Li alloys for Army Ballistic Missile Agency.

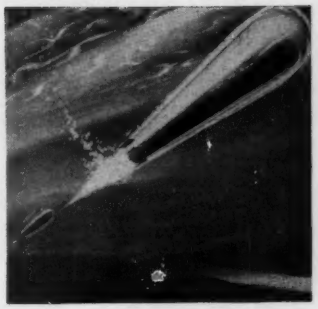
ONLY KNOWN MATERIAL which achieves yield strengths above 250,000 psi while maintaining a nil ductility temperature below −80 F . . . this is how International Nickel Co. characterizes its new 18 per cent nickel steel. Priced on a "realistic basis," the workable new "Mar-aged" steel is expected to find application in aircraft, ships, or wherever toughness and light weight are important.

OBJECTIONABLE WHITE LAYERS on nitrided steel parts—usually ground off—can now be removed by the Ban-Wite process, a new development by National Broach & Machine Co. In the patented treatment, nitrided parts are first coated with an impervious heat-resistant material, then heated under controlled conditions. According to the developer, the new technique also tends to increase case depth.

research/development

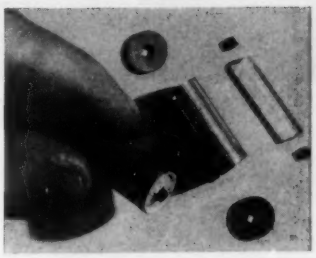
Convair Tries Heat on High-Speed Torpedoes

Doubling the speed of an underwater missile by encasing it in an envelope of gas is a real possibility, according to Convair scientists. Holding the potential for radical reduction in friction drag, the vapor layer can be created by heating the vehicle, or by covering it with a material that reacts with sea water to generate heat and gas. In tests of a super-heated (2000 F) graphite model, 1 ft long and 1½ in. in diam, Convair hydrodynamicists found that friction was 90 per cent less than for a cold graphite body. Project director Walter Bradfield anticipates the technique might be used in missiles like Polaris: ". . . there would be a great deal of value in permitting the missile to leave the ocean without dragging a great deal of water with it."



Ultrasonics Move up Microwave Scale

A transducer that converts electrical energy into ultrasonic energy in the microwave range has been developed by Bell Telephone Laboratories. Test models of the new piezoelectric unit—which incorporates a unique semiconductor "depletion layer" only 10^{-5} cm thick—have performed well at frequencies as high as 830 mc. Bell anticipates that improvements in circuits and fabrication will extend the range above 10,000 mc. While first applications will be designed to increase information capacity of ultrasonic delay lines, the transducer may eventually be used to yield more data on acoustical properties of materials at very high frequencies.



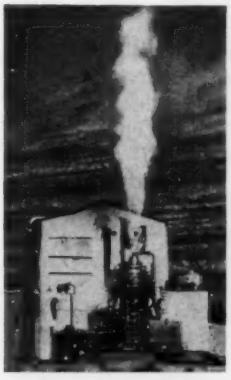
aero/space

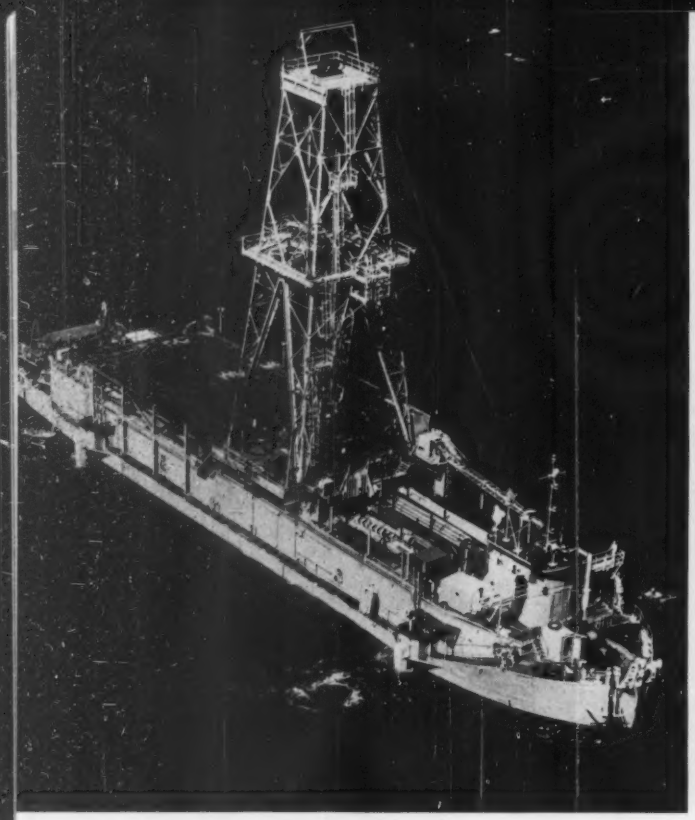
ATOMIC ENERGY COMMISSION has directed prime contractors to stop all work on nuclear-powered aircraft and engines. Affected by the decision are General Electric Co., Evendale, Ohio (working on the direct-cycle engine), and Pratt & Whitney Div., United Aircraft Corp. (indirect-cycle engine). AEC told contractors that it will shortly discuss with them their possible participation in a new $25 million program in the field of high-temperature materials.

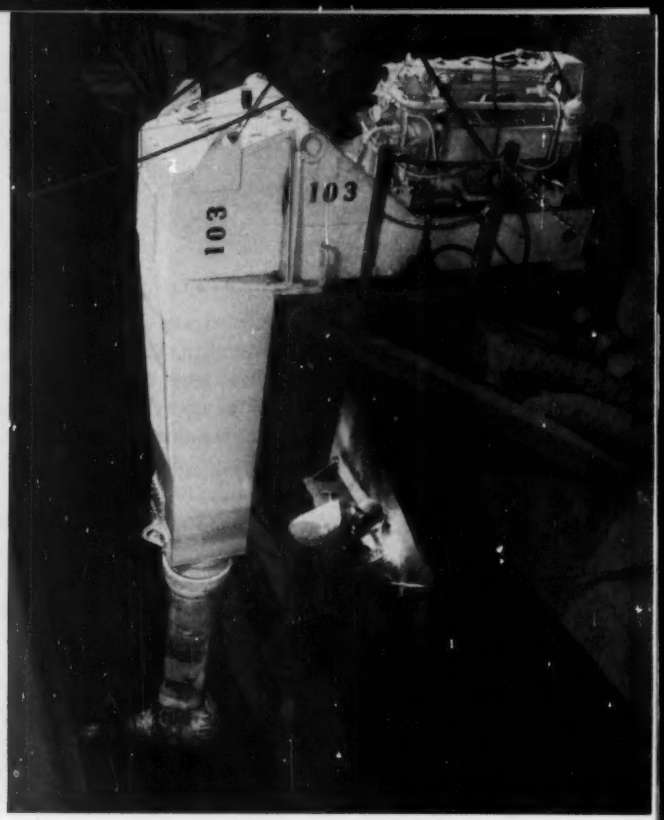
"HOTELEC"—an aviation electrical system that operates at temperatures from −65 F to 600 F—has successfully passed the breadboard stage at GE's Aviation Electrical Systems Laboratory. Developed for North American Aviation, Hotelec will need no auxiliary cooling to survive the thermal rigors of Mach-3 flight. GE's system comprises a special generator, regulator, and control equipment. Next step in the program is prototype construction and testing.

Kiwi Makes Progress

While the nuclear jet engine seems firmly grounded, well-funded progress continues in nuclear rockets. Air Force has awarded a $500,000 contract to Aerojet General's Nuclear Propulsion Div. for study of development requirements, facilities, scheduling, and costs associated with various engine designs. Acting as prime contractor for Air Force Flight Test Center, Aerojet is looking into design criteria for multi-million-pound nuclear boosters. Pushing a parallel program, the joint AEC-NASA office will soon select one of seven industrial firms responding to an invitation to assist Los Alamos Scientific Laboratory in developing and testing Kiwi-B.







Diesel Outboards Position

Joy-stick control of four engines holds ship within a " square block " of ocean

DYNAMIC positioning and catenary sag are not nautical terms bandied about by the ordinary seaman. But they comprised an obvious and critical problem to scientists working on the National Science Foundation's famed Project Mohole.

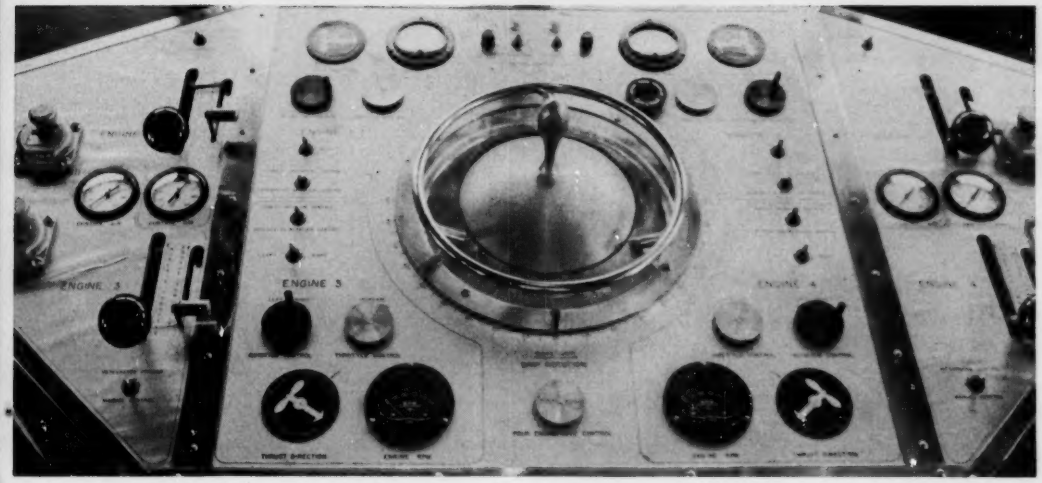
Mohole's success, which now seems assured, depends largely on the ability of the ship's pilot to maintain a relatively accurate position over a hole 2 to 4 miles below the surface of the ocean. The ship, in this case, is the *Cuss I*, a deep-sea drilling barge 260 ft long, with a displacement of 30 tons. Topped with a 98-ft high derrick, *Cuss* provides a platform from which a 4.5-in. diameter jointed drill string weighing well over 100 tons is lowered to the ocean floor. For the sake of the drill string, it becomes highly important to keep ship and hole in reasonable alignment.

Conventional anchors would be ineffective on *Cuss*. Even the tautest anchor wire, hanging in two miles of water, would sag in a deep catenary. The ship would be free to wander about in a mile-wide circle (radius equal to the scope of the catenary).

Solution to the problem is a dynamic positioning system: Winds and currents acting on *Cuss* are gaged by sonar; four steerable engines apply counter force.

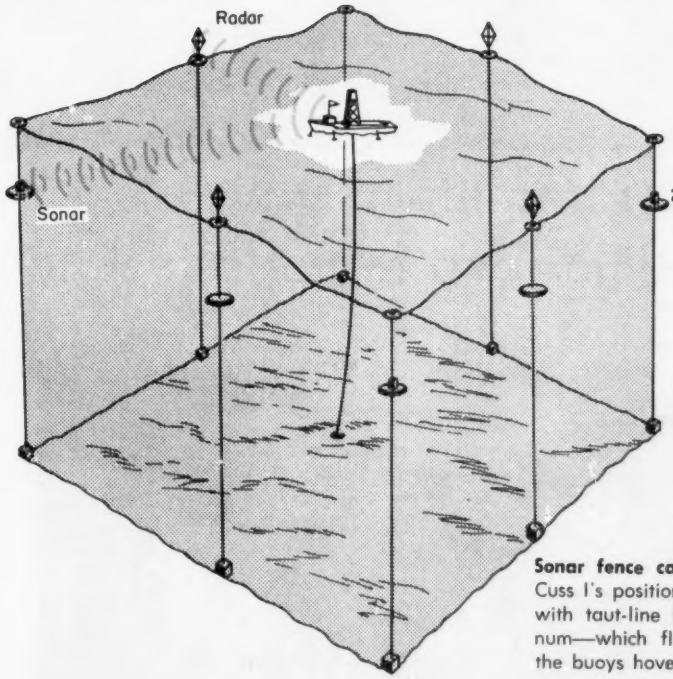
The sonar system, developed by Bendix-Pacific Div., Bendix Corp., consists of a transducer (underwater transmitter) suspended from the ship into the water and a series of four transponders (underwater receivers) arranged in a semicircle around the vessel. Signals relayed back to the ship by the transponders appear as blips on a sonar scope. An overlay on the scope, which shows a 180-deg azimuth to a range of 1000 yards, fixes the desired position of each of the transponders in relation to the transducer. If the ship drifts off course, the blip from one of the transponders moves away from its position on the overlay, warning the pilot to correct his position.

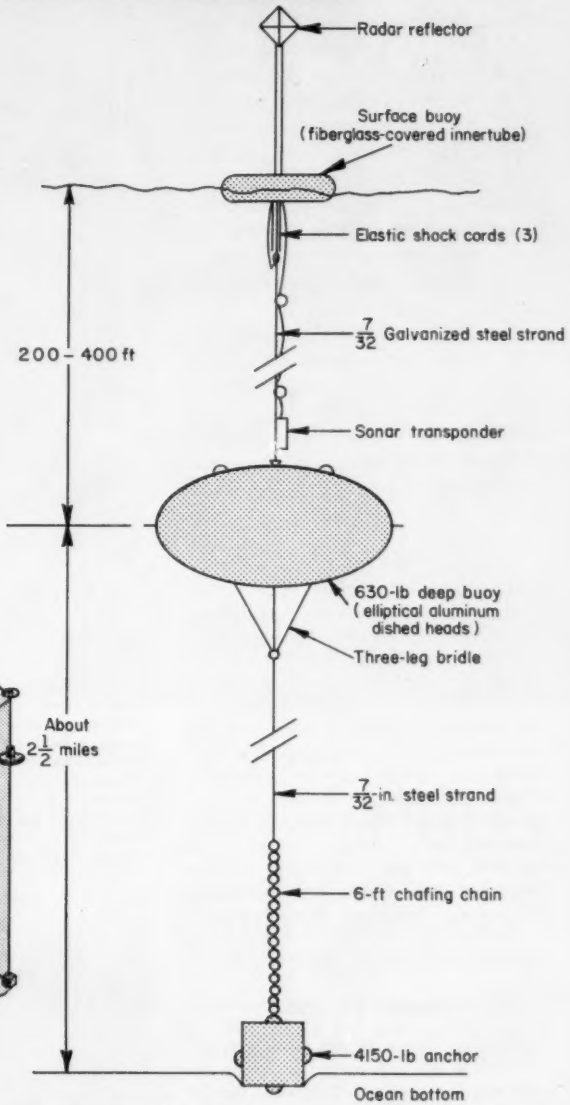
A coaxial cable, held in constant tension on the ship and terminating at an inclinometer anchored to the sea floor, backs up the radar-sonar system. The cable is an analog of the drill pipe so that any inclination of the meter represents a bending of the pipe where it enters the bottom. A two-co-ordinate recorder plots the information.



"Dynamic anchor" for Cuss I consists of four 200-hp diesel outboard engines (left) mounted on opposite corners of the ship. Thrust and direction of the engines can be varied simultaneously by a single control lever at the console (above). The system proved itself early this month by holding the ship over a bore hole almost 12,000 ft below the surface of the ocean. Console was designed and built by Robert Taggart Inc., Falls Church, Va.; GM supplied the engines; Murray and Tregurtha, Boston designed the outboards.

Mohole Rig





Sonar fence capped with radar reflectors provides a constant fix on Cuss I's position. Problem of keeping the fence in position was solved with taut-line buoys—6 ft-diameter oblate spheroids made of aluminum—which float well below the surface. Tethered by fine wires, the buoys hover within 100 ft of vertical.

European automakers colonized the U. S. with a few finely-bred sports cars. The heavy traffic that followed in foreign family-size cars is being curbed by American-made compacts. Observations made at the recent International Auto Show indicate that foreign manufacturers are retracing their steps, and the U. S. can expect . . .

More Sports Cars from Europe

PUBLIC interest and participation in sports-car events have increased geometrically during the past five years. Races and rallies are held almost every day, crowds at tracks are setting records, and new and faster tracks are being built. The Sebring, Fla., Grand Prix, granted to the U. S. (by Federation International d'Automobile) just three years ago is helping the sports-car cause by attracting world-championship drivers to the U. S.

European sports-car manufacturers, whose only competition here is offered by GM's Corvette, apparently intend to bolster their commanding lead—they introduced a number of new models at the recent International Auto Show in New York.

Jaguar XK-E

"The fastest production car ever offered for public sale" was introduced in two models by Jaguar. Powered by a 265-hp engine, the new XK-E model will exceed 150 mph in standard production form. Its body construction is based on the patented stressed-shell monocoque design developed for the famous D-Type racing cars. Independent rear suspension, a departure for Jaguar, includes four coil springs, two per wheel, each enclosing a hydraulic shock absorber. The car is equipped with rack and pinion steering, four-wheel disk brakes, and limited-slip differential. Four-speed manual gearbox is standard; no overdrive or automatic is available. Price of the roadster: $6000.

Daimler S.P. 250

Daimler, now a Jaguar subsidiary, introduced a fast two-seater that boasts the difficult, but typically European, feat of combining economy and performance. The car will accelerate from 0 to 60 in 10 seconds, has a top speed of around 135 mph, but has averaged 26.6 mpg in

Specifications	Jaguar XK-E	Daimler SP-250
Engine type	6-cyl, ohv	V-8
Displacement (cu in.)	230.6	152.6
Bore & stroke (in.)	3.42×4.17	3.00×2.75
Compression ratio	9:1	8.2:1
Power, max (bhp)	265 @ 5500	140 @ 5800
Torque, max (lb-ft)	260 @ 4000	155 @ 3600
Wheelbase (in.)	96	92
Length (in.)	175.3	160.5
Width (in.)	65.2	60.5
Height (in.)	48	50.2
Weight, empty (lb)	2464	2090

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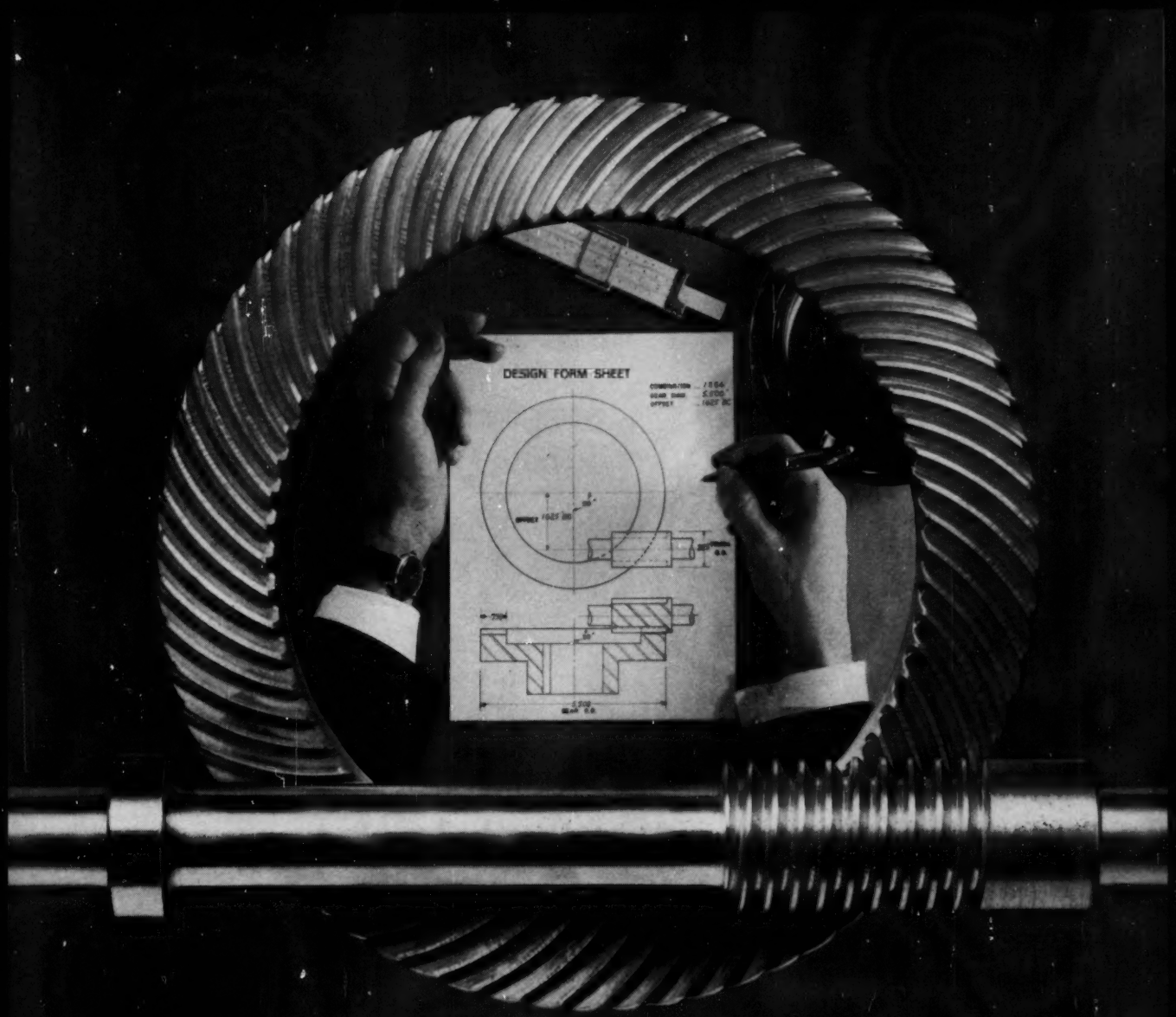

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If you want to make your transmission more quiet or more compact or more flexible, take a good long look at the HRH set shown above.

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1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Circle 214 on Page 19

How wood engineering helps improve skiers in July

THE "BONGO BOARD" (above) is an exercise and balancing device which, among many other recreational uses, is popular with skiers as an off-season training aid.

When Bongo Corporation came to Gamble Brothers, seven years ago, they needed a supplier who could produce platforms and rollers which would retain dimensional stability despite repeated twisting and hard pounding; which would not scuff carpets or damage floors when used inside; which would operate smoothly and quietly; and which could be produced at low unit cost. Gamble Brothers' facilities and experience "filled the bill" then, and still do now.

Problems like this are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

Specifications	Volvo P-1800
Engine type	4-cyl, ohv
Displacement (cu in.)	108.5
Bore & stroke (in.)	3.31×3.15
Compression ratio	9.5:1
Power, max (bhp)	100 @ 5500
Torque, max (lb-ft)	108 @ 4000
Wheelbase, (in.)	96.5
Length (in.)	173
Width (in.)	67
Height (in)	51
Weight (lb)	2500

recent 1000-mile road tests. Speed of 134 mph was attained during the economy run.

A fiber-glass body contributes to Daimler's scant 2280-lb weight, and the car is equipped with independent front suspension, cam-type steering, disc brakes, and a four-speed gearbox. Automatic and overdrive are optional. Price: About $4000.

Volvo P-1800

Not a true wind-in-the-face sports car, Volvo's new p-1800 is patterned after the popular European Grand-Touring class of automobiles. Design of the car is fairly straightforward: Unitized body with independent front suspension. Disc brakes are used in front, drums in the rear (where only one-third of the braking effort is carried). Top speed is about 105 mph; over-the-shoulder safety belts are standard equipment.

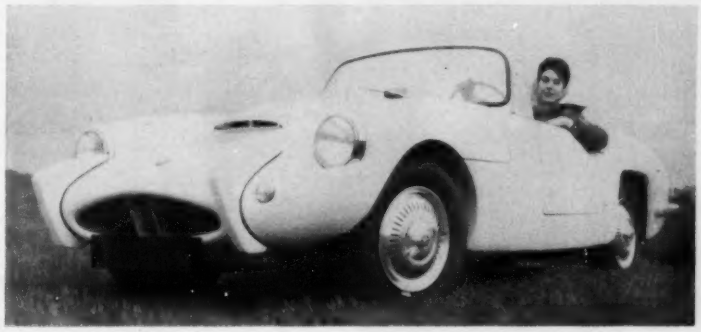
GSM Delta

Powered by a Ford 105E engine (Anglica and Prefect), the Delta has experienced success in European racing circles, but is relatively unknown here. The car has a tubular steel chassis capped with a fiber-glass body. Its engine performance is relatively impressive—the standard 105E develops 30 hp @ 5000 rpm; reworked (but not bored) for Delta it provides 60 hp and a top speed of 105 mph.

Specifications	GSM Delta
Engine type	4-cyl, ohv
Bore & stroke (in.)	3.19×1.90
Displacement (cu in.)	61
Compression ratio	8.9:1
Power, max (bhp)	60 @ ....
Wheelbase (in.)	87
Length (in.)	145
Width (in.)	60.5
Height (in.)	46
Track (in.)	48

New Country Heard From

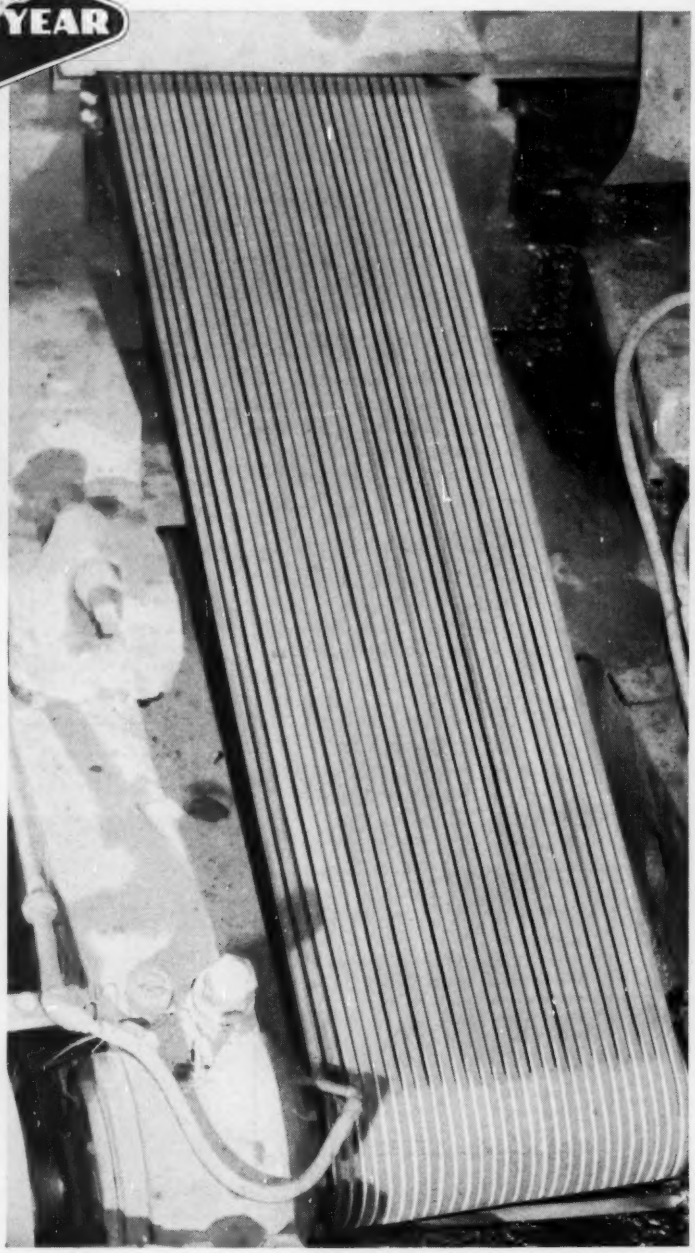
Israel's Sabra Sportster is designed with American and British export in mind. Ford powered (Consul engine), the Triumph-size roadster also uses Consul's windshield, door handles, and other miscellaneous hardware. Body of the car is an assembly of six easily replaced fiber-glass panels mounted on a box-section frame. Independent engine-cooling system uses a pressurized cross-flow radiator with a thermostatically controlled electric fan. Top speed of the car is 100 mph; price, about $3000.



Specifications	Sabra Sportster
Engine type	4-cyl, ohv
Bore & stroke (in.)	3.25×3.13
Displacement (cu in.)	103.9
Compression ratio	7.8:1
Power, max (bhp)	61 @ 4400
Torque, max (lb-ft)	91 @ 2300
Wheelbase (in.)	90
Length (in.)	165
Width (in.)	51
Height (in.)	50
Track (in.)	48
Weight (lb)	1756

GOODYEAR EXCLUSIVE! IS YOUR SIGN OF V-

Goodyear V-Belts' precision matching comes from this exclusive close-tolerance matching equipment that length-codes each belt to 1/32". Most other belt manufacturers code only to 1/10".



Goodyear V-Belts' precision matching assures standout performance. Example: only 28 COMPASS-V-Steel Belts handle this big steel saw, normally calling for 42 belts. Result: the steel mill saved $500 at the original installation – will save more at every belt change.

THE GREEN SEAL BELTS CODED TO 1/32"

Here's your assurance that every belt in a set matches in length – pulls together for maximum trouble-free horsepower hours

What's more, the Green Seal means –

Dimensional stability that lasts the life of the belt–thanks to shrink- and stretch-resistant "muscles" of 3-T Process Cord or airplane-type steel cable built into each belt.

Satisfactory performance even when subjected to dampness – because of special mildew-inhibited compounds.

The most complete line of V-Belts anywhere today – always within easy reach through a nationwide network of distributor stocks.

The proper selection of V-Belts to meet your requirements with the help of the G.T.M.– Goodyear Technical Man – America's top belting specialist.

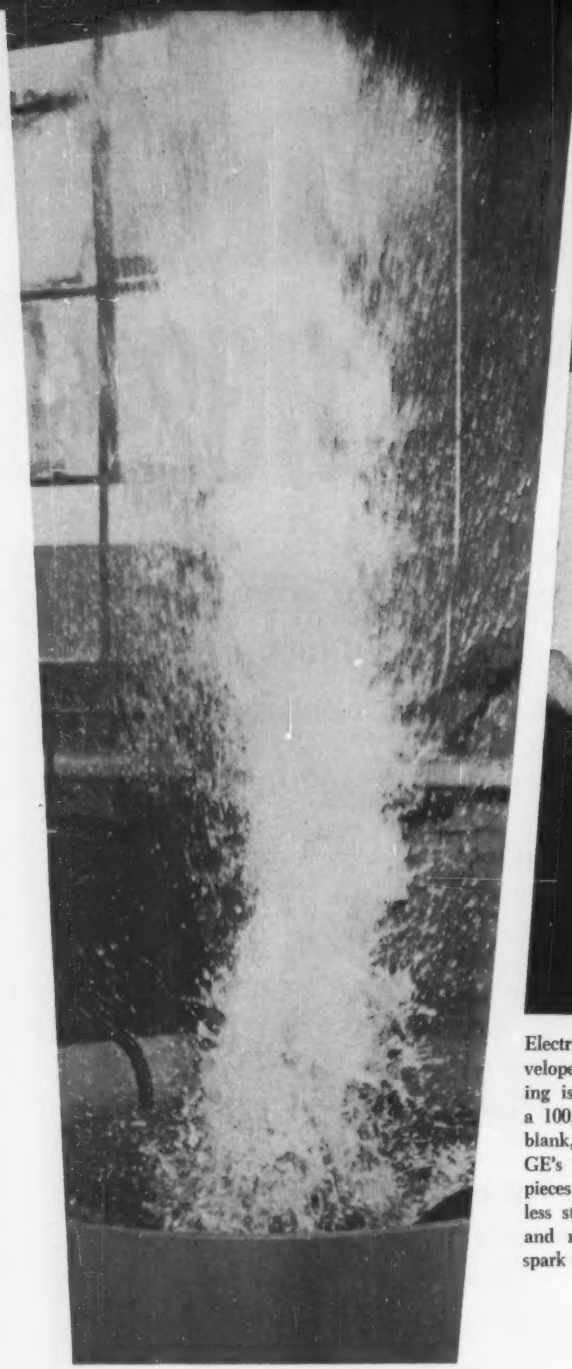
So make the GREEN SEAL your sign of savings–in both time and money–by calling your Goodyear Distributor. Or write Goodyear, Industrial Products Division, Akron 16, Ohio.

Lots of good things come from

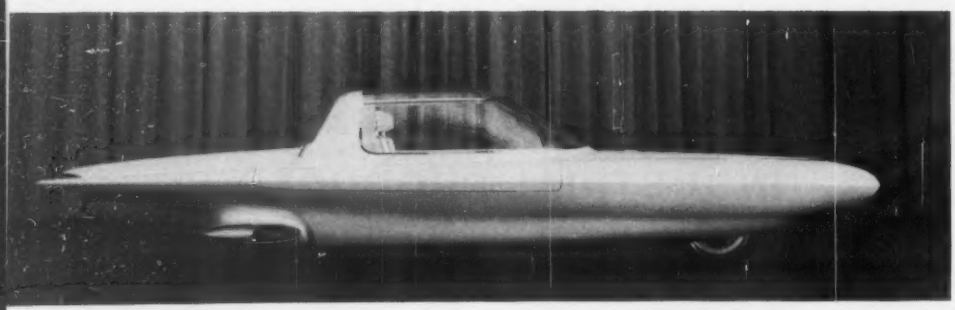
GOODYEAR

INDUSTRIAL PRODUCTS

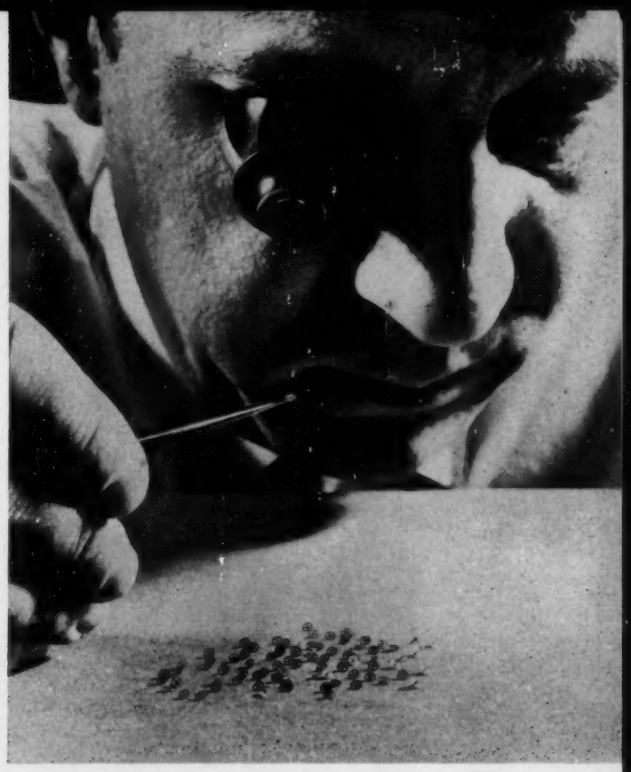
Green Seal, Compass–T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio



Electricity eliminates explosives in an underwater metal-shaping process developed by General Electric Co. for hard-to-form metals. Electro-spark forming is done with a built-up jolt of electricity—35,000 v are used now, and a 100,000-v shock is predicted. The high-intensity shock waves hit a metal blank, blowing it into a die, which is evacuated to prevent air pockets. GE's General Engineering Laboratory has successfully shaped 10-in. diam pieces of titanium, niobium, beryllium-copper, and "difficult" grades of stainless steel; not yet tested, but expected to be added to the list are tungsten and molybdenum. Unlike shaping with chemical explosives, the Electro-spark process can be used in the same area as other manufacturing operations.



Ford's first two-wheeler, the Gyron would depend on a 2-ft diameter gyroscope for stabilization. Other unusual features proposed for this delta-shaped dream car are a built-in computer (useful in programming journeys on non-stop highways) and power from fuel cells. Changing drivers in the Gyron could be accomplished without even slowing down: The foot bar in front of each contoured seat has a brake and accelerator pad, and steering is done with a dial instead of a wheel.

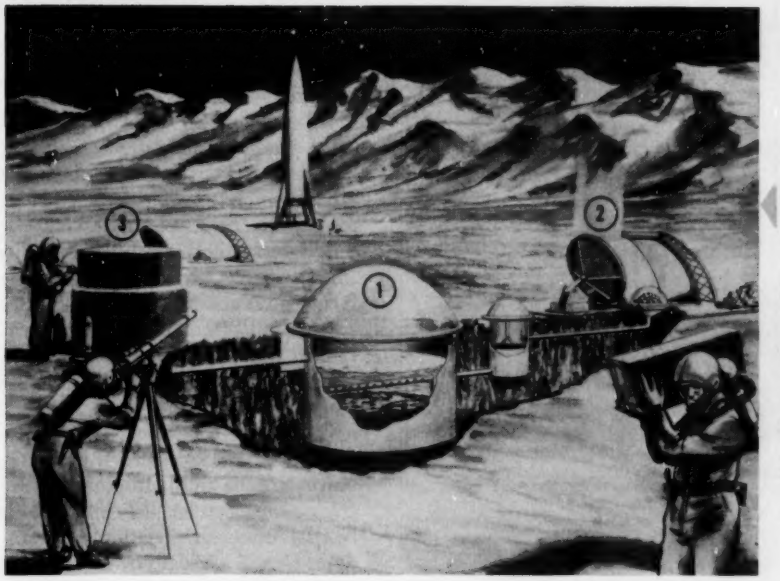


Three hundred precision-machined teeth of a gear for the Accutron electronic wrist watch are examined here by Max Hetzel, chief physicist of Bulova Watch Co. Inc. and inventor of the Accutron. The watch, cited as the year's most significant contribution to miniaturization, received the 1960 Miniaturization Award sponsored by Miniature Precision Bearings Inc. Other winners are: Electro-Optical Systems Inc.; Spard Div., Electric Autolite Co.; Ethicon Inc.; General Electric Receiving Tube Dept.; A. W. Haydon Co.; Aerospace Engineering Div., Hughes Aircraft Co.; Federal Systems Div., International Business Machines Corp.; Sandia Corp.; and Vickers Inc., Div. of Sperry Rand Corp.

ENGINEERING NEWS

PICTURE REPORT

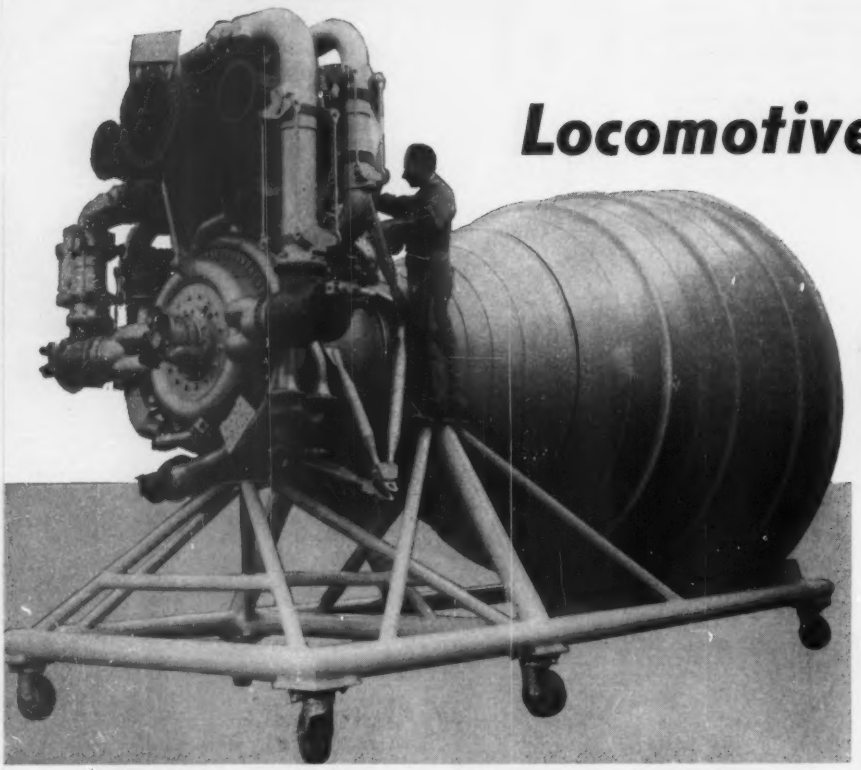
Airlifting 30 tons of cargo approximately 3400 miles will be possible with the C-141 turbofan transport to be built by Lockheed Aircraft Corp. for the Air Force. Carrying a lighter payload (10 tons), the aircraft will fly 6300 miles—nonstop across the Pacific. Designed for loading at truck-bed height through the aft fuselage, the C-141 will also be able to drop supplies and personnel by parachute. This jet freighter is scheduled for delivery to the Military Air Transport Service in 1965; Lockheed's Marietta, Ga., division will build it.



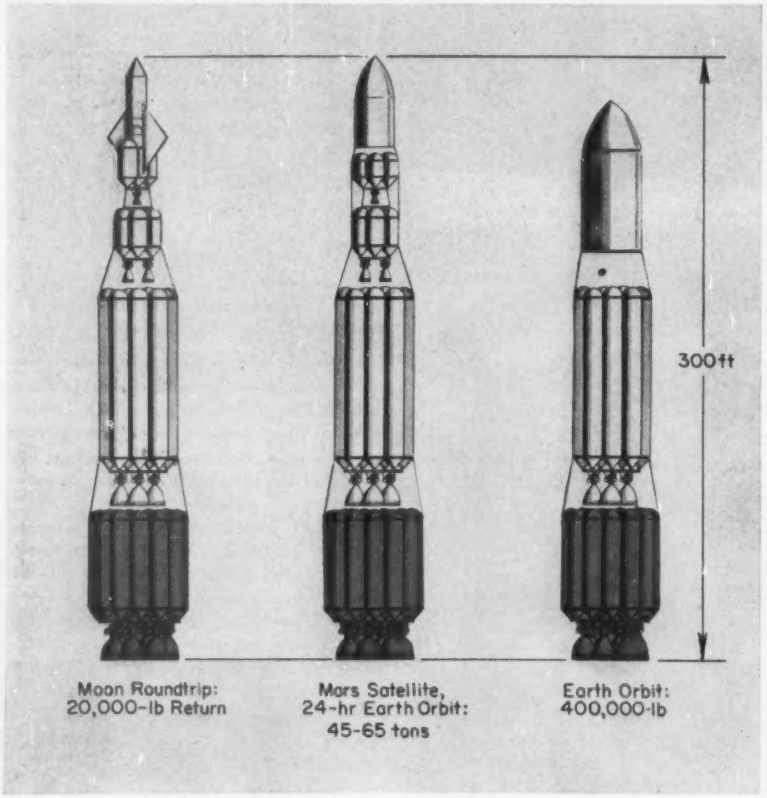
Busy corner of the moon shows a powerplant and a lunar garden as visualized by Dr. Fritz Zwicky, consultant to Aerojet-General Corp. and professor of astrophysics at California Institute of Technology. A solar furnace (1) could provide water, oxygen, nitrogen, propellant, power, and food. Astronauts could produce steam to drive turbines by focusing the sun's rays (with flat and concave mirrors) on a pile of lunar rocks which contain 1 to 10 per cent water (2). Water derived would be used for drinking and growing algae, and oxygen could also be drawn from it and stored for replenishing air tanks (3).

Locomotives for Space

Rated at 1,500,000 lb thrust, Rocketdyne's forthcoming F-1 engine will provide the power for boxcar-size satellites



F-1 Mockup (above) shows unusual size of the engine. It will weigh about 15,000 lb. operational. Typical Nova vehicles (below), all with six-engine F-1 boosters, will have various heavy-duty capabilities.

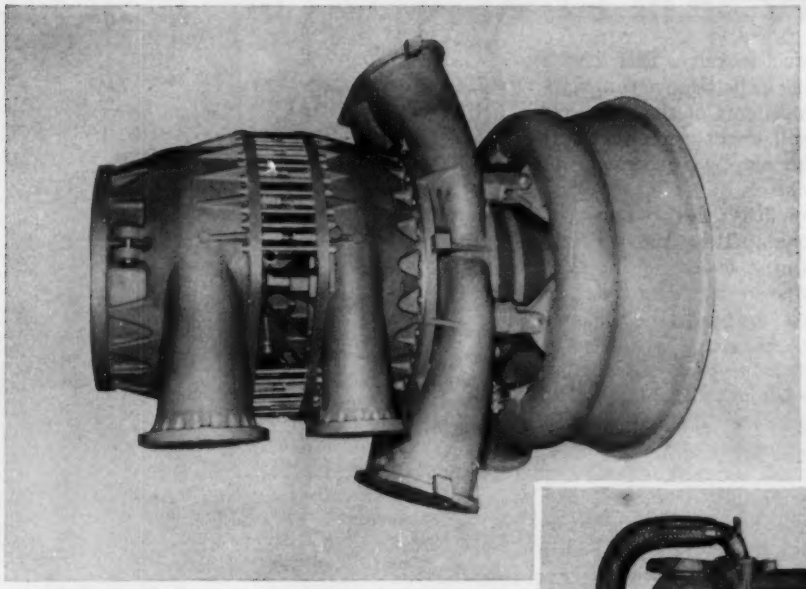


DURING a few short months in 1957, the conservative nature of U.S. rocket-engine development was painfully exposed. In rapid succession, the Soviet Union launched satellites weighing 184 lb and 1120 lb, respectively. The first U. S. satellite weighed 31.5 lb; the second, a mere 3.5 lb.

Since that time, the U.S. approach to space has been described as being more sophisticated, scientifically, than that of our competitors—the penalty of low-power boosters is being overcome by incredible (and costly) miniaturization of payload instrumentation.

In another year or two, our dedicated experts in miniaturization may be able to relax. Many of them are already pondering the wide-open payload space offered by the forthcoming (1962-63) 1.5-million-lb-thrust Saturn booster. And if they have trouble filling the nooks and crannies in a 20,000-lb Saturn-launched probe, the proposed Nova series of boosters will give them a real challenge.

Currently scheduled to follow Saturn in NASA's space itinerary, Nova will be built around the F-1 engine now under development at North American Aviation's Rocketdyne Div. A typical Nova, using six



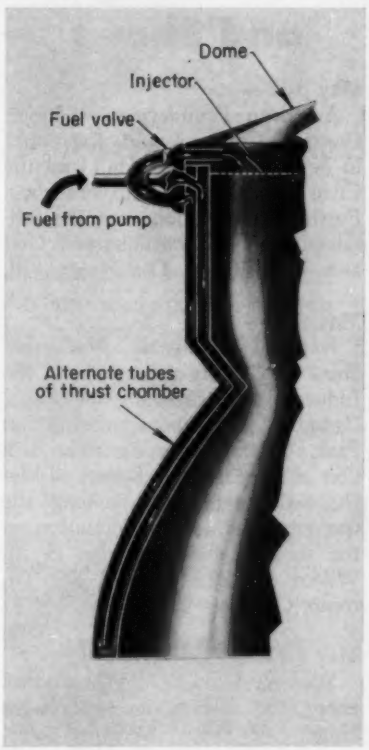
Three tons of fuel and oxidizer per second will be moved by F-1's powerful propellant turbopump (above). Driven by the 10-in. diameter gas generator (right), the pump develops approximately 60,000 hp at rated operation. It weighs 2500 lb; measures about 4 ft in diameter, 5 ft long. Gas generator burns a fuel-rich mixture of lox and kerosene, consumes 2 per cent of the total propellants used in the engine.

F-1 engines in cluster, will be capable of low-orbiting 400,000 lb . . . or roughly the weight of four fully loaded boxcars. Its missions will vary from the establishment of manned laboratories for astronomical and earth observation, to the launching of large space platforms assembled in 400,000-lb increments by multiple-launch and rendezvous techniques. It would also permit manned interplanetary vehicles to be assembled and fueled while in "parking orbit."

Another typical Nova vehicle would be capable of launching a 65-ton payload into 24-hr orbit (22,000-mile altitude) for astronomical observation, earth surveillance, navigational systems, and weather observation. A vehicle of this same configuration could put 90,000 lb into a Mars orbit, from which robot probes would be launched to the surface of the planet, relay telemetered information back to earth.

Using the same six-engine F-1 cluster, with high-energy upper stages, Nova would also open the door to manned moon landings and return. The return vehicle would have an earth-landing weight of approximately 20,000 lb.

Designers of the F-1 are benefiting from a decade of prolific research



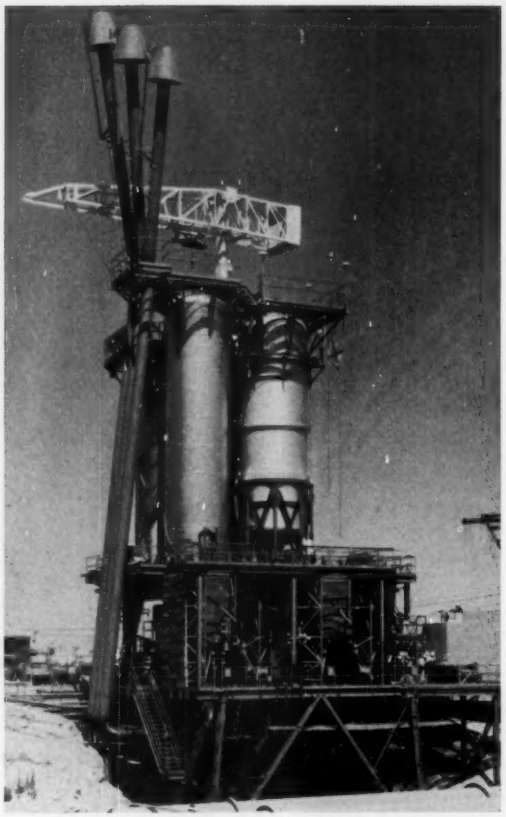
Thrust-chamber assembly consists of the conventional regeneratively cooled tubular-wall structure, plus an oxidizer dome, four integral fuel valves, and a flat-face injector. Oxidizer is fed through dual inlets to the dome where it is injected through a pattern of 2600 orifices into the combustion chamber. Fuel enters through dual inlets to a chamber-feed manifold, flows through alternate tubes the length of the chamber, and returns to the fuel-collector manifold. From here, it flows through four poppet valves spaced 90 deg around the chamber and into an injector-feed manifold, where it is distributed through 32 spokes into the injector. It then passes through approximately 3700 orifices into the combustion chamber.

in liquid-fuel rocketry. Their engine reflects this in its relative simplicity. Basic components of the F-1 are a tubular-wall thrust chamber, direct-drive turbopump, gas generator, and related controls.

For simplicity and compactness, the turbopump is mounted directly on the thrust chamber. All other components are either mounted on these two assemblies, or in the plumbing between. Thrust-vector control is achieved by gimballing the entire engine; there is no flexing of high-pressure ducting. Fuel, at high pressure, is used as the hydraulic actuating medium.

Success, or lack of success, with Saturn will undoubtedly influence the fate of the F-1. If the Saturn clustering technique proves effective and reliable, and if advancements in solid-fuel or nuclear technology don't force liquid fuel out of the picture, the F-1 will play a major role in U. S. space exploration.

Reports from Rocketdyne indicate that development of the F-1 is right on schedule, meaning that the engine will be operational in 1963.



Turbopump required its own test stand during F-1 development. The stand accommodates three test turbopumps which are driven by permanently mounted gas generators.

Meetings and Shows

May 8-12—

American Foundrymen's Society. Castings Congress and Exposition to be held at Brooks Hall and the Civic Auditorium, San Francisco. Further information can be obtained from AFS headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 8-12—

National Industrial Production Show of Canada to be held at the Industry and Coliseum buildings, Canadian National Exhibition Park, Toronto. The Canadian section of the American Society of Mechanical Engineers is among the sponsors. Additional information on the show is available from E. M. Wilcox Ltd., 19 Melinda St., Toronto, Canada.

May 9-11—

Western Joint Computer Conference to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from conference headquarters, 5909 W. Third St., Los Angeles 36, Calif.

May 9-12—

American Society of Mechanical Engineers. Production Engineering Div. Conference to be held at the Royal York Hotel, Toronto. Further information is available from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

May 10-12—

Society for Experimental Stress Analysis. Spring Meeting to be held at the Benjamin Franklin Hotel, Philadelphia. Further information can be obtained from SESA headquarters, 21 Bridge Square, Westport, Conn.

May 14-17—

National Fluid Power Association. Spring Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Further information is available from association headquarters, 5595 N. Hollywood Ave., Milwaukee 17, Wis.

May 15-16—

American Institute of Electrical Engineers. Packaging Industry Technical Conference to be held at the New Ocean House, Swampscott, Mass. Additional information is available from AIEE, 33 W. 39th St., New York 18, N. Y.

May 21-23—

Fluid Controls Institute Inc. Annual Meeting to be held at the Cloister, Sea Island, Ga. Further information is available from FCI headquarters, P. O. Box 667, Pompano Beach, Fla.

May 22-24—

National Telemetering Conference to be held at the Hotel Morrison, Chicago. Sponsors are Institute of the Aerospace Sciences, Institute of Radio Engineers, Instrument Society of America, American Rocket Society, and American Institute of Electrical Engineers. Additional information can be obtained from IAS, 2 E. 64th St., New York 21, N. Y.

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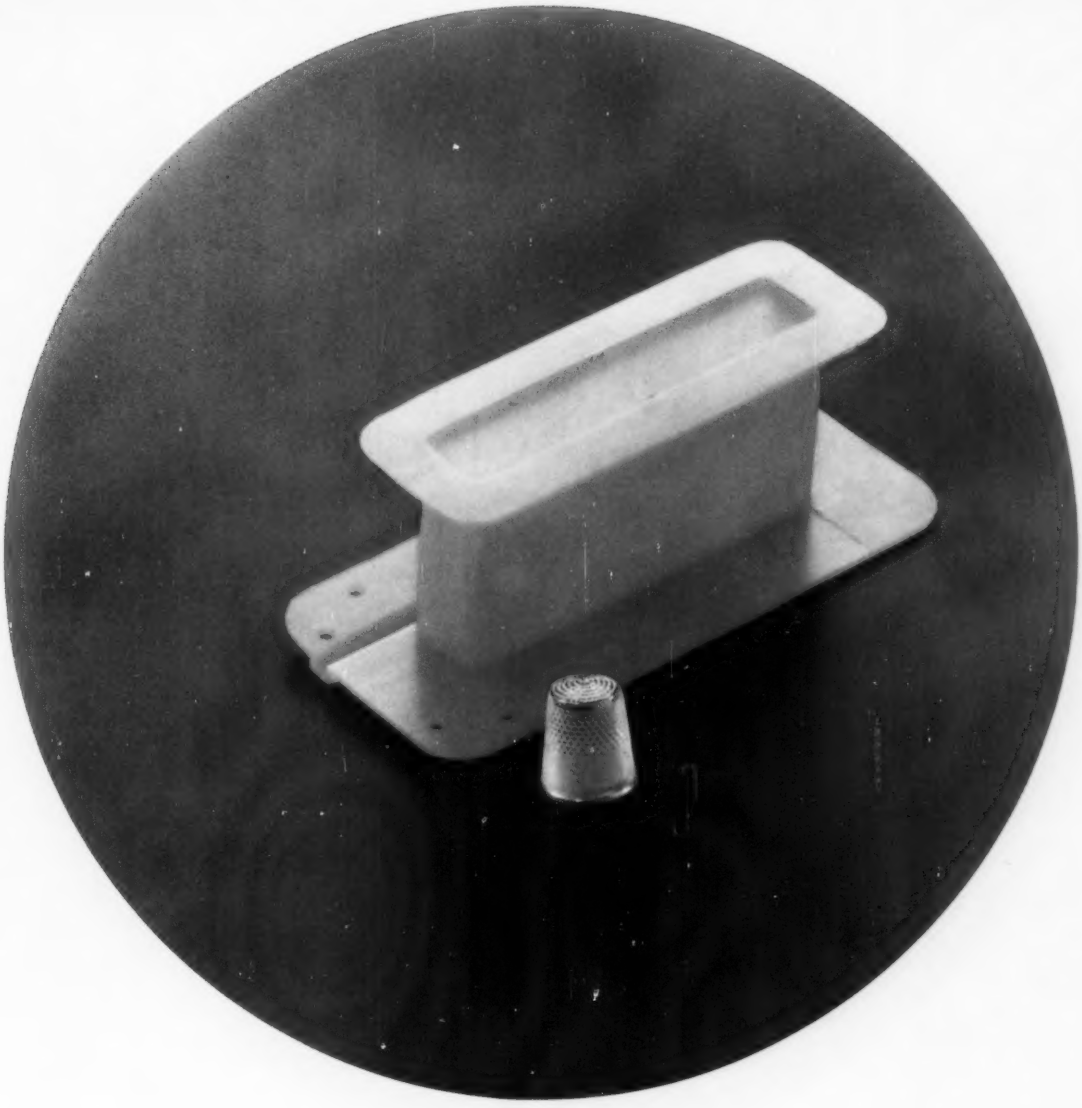
Plaskon NYLON 6, GLASS-FILLED, TAKES HEAT, STRESS



Bobbins made of Plaskon Nylon 6 reinforced with glass fiber (shown above with thimble for size comparison) contribute to a better exciter generator, reports Electric Machinery Mfg. Co. of Minneapolis, Minn. The manufacturer says: "The molded bobbins are a **durable** and **economical** means of providing the field winding in one unit for insertion on the pole."

Glass fiber reinforced Nylon 6 has greatly improved dimensional stability, excellent moisture resistance and extremely high heat resistance — permitting intermittent use above 400 degrees F. Tensile strength is high (30,000 psi), as is resistance to distortion caused by winding.

The molding compound used in this bobbin, Nylafil G3, consists of Plaskon Nylon formulated with glass filler in a rigidly controlled process by Fiberfil, Inc., Warsaw, Ind.

PLASKON NYLON 6 OFFERS:

- toughness
- rigidity
- light weight
- lower shrinkage
- greater impact strength
- easier colorability
- moisture resistance
- abrasion resistance
- corrosion resistance
- heat resistance
- lower molding temperatures

Take advantage of these hard-working properties for your product—specify Plaskon Nylon. Write now for technical data on Plaskon Nylon and Nylafil G3.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS

Plaskon WOOD-FLOUR FILLED UREA...EFFICIENT

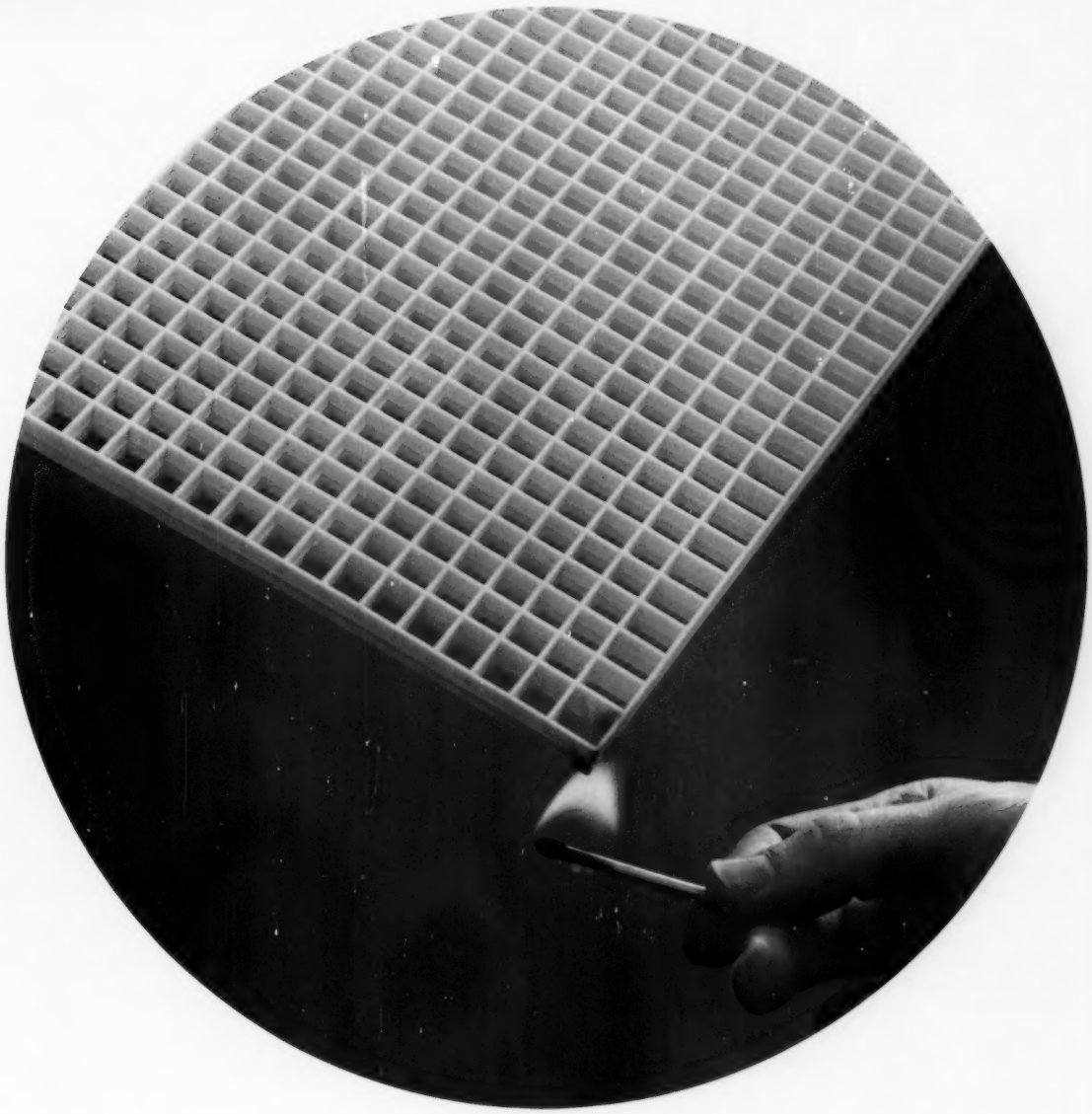
Efficient both electrically and economically, this Plaskon Wood-Flour Filled Urea circuit breaker case delivers superior arc resistance . . . 80-100 seconds (ASTM). The maker states that its dielectric and insulating properties have proven satisfactory in this circuit breaker case, as well as other cases in his line.

Allied Chemical Corporation developed this material specifically for high-speed automatic molding of electrical parts; Plaskon Wood-Flour Filled Urea is now thoroughly proven in the field. It matches or exceeds the more expensive alpha-cellulose urea in all properties except translucency and color range. Available in NEMA brown or standard black.

Other important properties of Plaskon Wood-Flour Filled Urea: Superior color-fastness • Impervious to household solvents • Non-electrostatic surface.

You may well profit by switching to Plaskon Wood-Filled Urea . . . write us for more information and for samples.

FIRE-RESISTANT UREA . . . NON-STATIC, TOO



Lighting grids like this made of Plaskon Fire-Resistant Urea UFR-28 stand up well to flame!

Where the UL fire tunnel test may cause other white and pastel materials to blister, drip or contribute readily to flame spread, this grid has a low UL flame spread rating of 25 . . . considered "Non-Combustible" in general practice! In addition, its ASTM rating is "Non-Burning."

Called "N. C. Gratelite" by maker Edwin F. Guth Co., St. Louis 3, Mo., this new grid eliminates static electricity charges, too . . . doesn't attract dust.

Other important properties of Plaskon Fire-Resistant Urea UFR-28 . . . high dielectric strength; rigid enough to support itself; hard surface resists scratching and abrasion and facilitates cleanup; colors are spectro-photometrically controlled for precise lighting values.

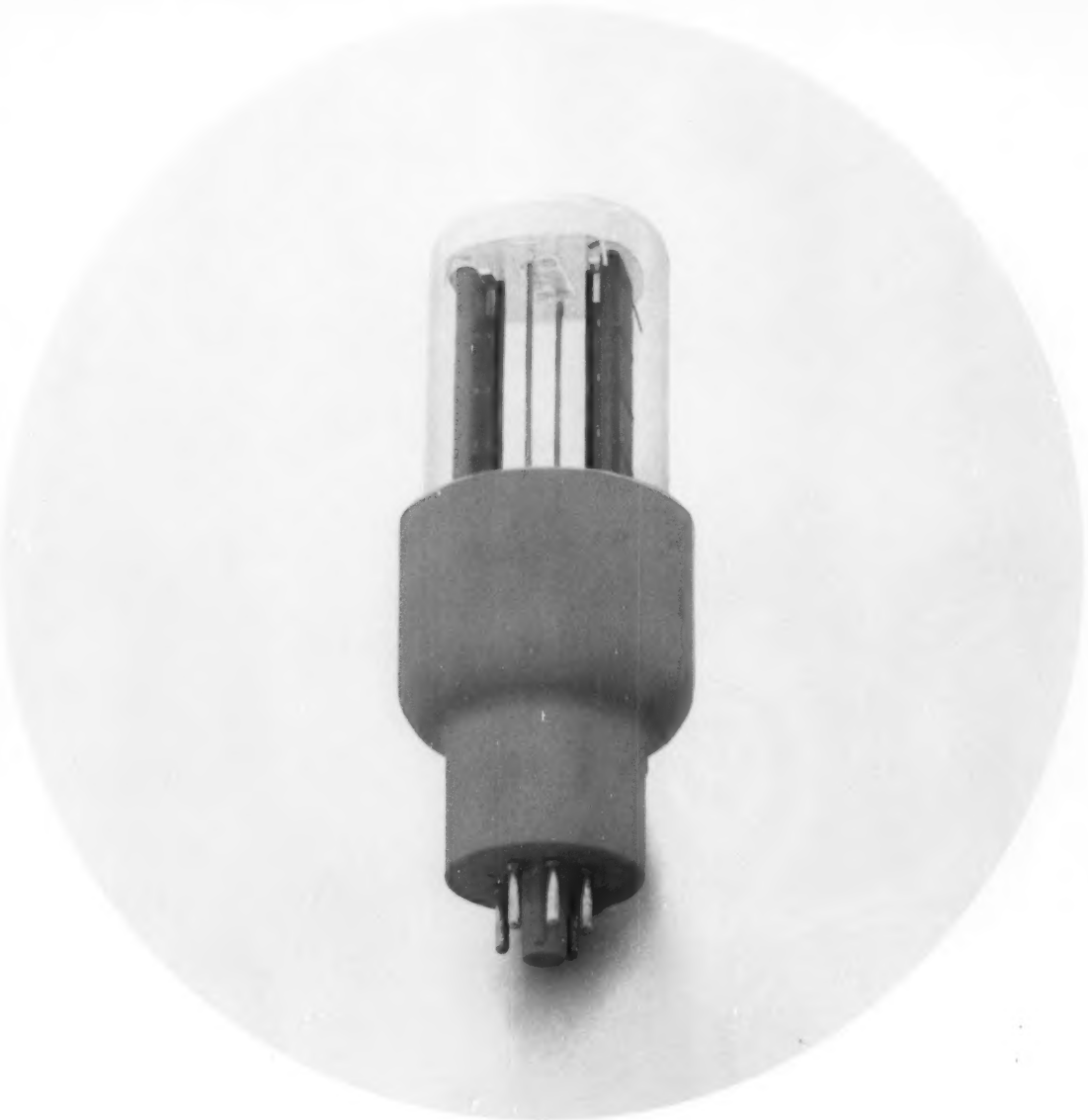
Look to Allied for Urea Molding Compounds when you need good fire resistant and electrical properties, rigidity, strength, wide color range, or combinations of these. Plaskon materials and know-how to help solve your problems are freely available. We'd like to hear from you.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS

Plaskon® ALKYDS PROVIDE HIGHEST ARC RESISTANCE



The base of this rectifier tube is made of Plaskon Alkyd Molding Compound. The tube's maker, Chatham Electronics, Division of Tung Sol Electric, Inc., states that . . .

1. Plaskon Alkyds provide high arc and insulation resistance. A three kilovolt potential between base pins presented no problem.
2. The high mechanical shock resistance of Plaskon Alkyd helps this tube to withstand 900 G's, as required by military specification.
3. In this application, a maximum bulb temperature of 250°C (482°F) has no adverse effect on the Plaskon Alkyd base.
4. The fast cure rate, dimensional stability and uniformity of Plaskon Alkyd permit high-speed, high-precision parts production.

Plaskon Alkyd Molding Compounds are available in three forms . . . free-flowing granular for high-speed automatic molding; glass-reinforced impact grades combining excellent mechanical and electrical properties; putty types for encapsulation. For more about Plaskon Alkyd Molding Compounds, write or call our Alkyd sales department.

PLASTICS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

BASIC TO AMERICA'S PROGRESS

(*Continued from Page 36*)

May 22-25—

Design Engineering Show and Conference to be held at Cobo Hall, Detroit. Conference is sponsored by the Machine Design Div. of ASME. Further information is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 22-26—

American Society of Tool and Manufacturing Engineers. Convention and Tool Exposition to be held at the Coliseum, New York. Additional information is available from ASTME headquarters, 10700 Puritan Ave., Detroit 38, Mich.

May 22-26—

Society of Photographic Scientists and Engineers. National Conference to be held at the Arlington Hotel, Binghamton, N. Y. Further information can be obtained from SPSE, Box 1609, Main Post Office, Washington, D. C.

June 4-8—

American Nuclear Society. Annual Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information can be obtained from O. J. DuTemple, 86 E. Randolph St., Chicago 1, Ill.

June 4-9—

Society of Automotive Engineers Inc. Summer Meeting to be held at the Chase-Park Plaza Hotel, St. Louis. Additional information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

June 5-7—

American Gear Manufacturers Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. Further information is available from AGMA headquarters, 1 Thomas Circle, N.W., Washington 5, D. C.

June 5-9—

Society of the Plastics Industry Inc. Ninth National Plastics Exposition and National Plastics Conference to be held at the Coliseum and the Commodore Hotel, New York. Additional information can be obtained from SPI headquarters, 250 Park Ave., New York 17, N. Y.

June 6-8—

Instrument Society of America. Summer Instrument - Automation Conference and Exhibit to be held at the Royal York Hotel and Queen Elizabeth Hall, Toronto, Ont. Further data is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

June 8-9—

Malleable Founders Society. Annual Meeting to be held at the Broadmoor, Colorado Springs, Colo. Additional information can be obtained from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

June 8-9—

National Electrical Manufacturers Association. First Western Conference to be held at the Biltmore Hotel, Los Angeles. Further information is available from NEMA, 155 E. 44th St., New York 17, N. Y.

June 11-15—

American Society of Mechanical Engineers. Summer Annual Meeting to be held at the Statler Hilton Hotel, Los Angeles. Additional information can be obtained from ASME Meetings Dept., 29 W. 39th St., New York 18, N. Y.

June 13-15—

Institute of the Aerospace Sciences - American Rocket Society. Joint Summer Meeting to be held at the Ambassador Hotel, Los Angeles. Further information is available from IAS, 2 E. 64th St., New York 21, N. Y.

Short Courses and Symposia

May 8-10—

Fourth National Power Instrumentation Symposium, sponsored by Instrument Society of America, to be held at the La Salle Hotel, Chicago. Additional information can be obtained from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 9—

Technical Conference on Plastics in the Automotive Industry, sponsored by the Detroit section of the Society of Plastics Engineers Inc.,

(*Please turn to Page 44*)

←Circle 217 on Page 19

1961 DESIGN ENGINEERING

and Concurrent ASME Conference

Put those important product drawings and specifications in your briefcase. Make a list of original equipment you want to know more about. Get a big notebook, and pack a pair of comfortable walking shoes. Then head for Detroit's magnificent new Cobo Hall and the biggest, most exciting Design Engineering Show in history.

The best design and development work that over 350 companies can come up with is ready for you to see, compare, and study. The top application engineers of these companies will be on hand to discuss their products with you – go over drawings and specifications – make suggestions – offer you the benefit of their cumulative experience.

SHOW COBO HALL Detroit · May 22-25

Everyone with design-engineering responsibility will benefit from DESIGN WEEK IN DETROIT – and every company will profit by *making sure* its design-responsible executives and engineers have this once-a-year chance to see the latest and best in original equipment. There are three mornings and evenings of concurrent ASME Conference sessions waiting for you, too – all devoted to "*Designing for the Competitive Market*". There is much for you in every one of the Conference's 24 major papers.

For hotel reservations write the Detroit Convention & Visitors Bureau. For other information contact:

CLAPP & POLIAK, Inc. *Exposition Management*
341 Madison Avenue • New York 17 • MUrray Hill 4-3432

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(*Continued from Page 41*)

in co-operation with SPE Plastics in the Automotive Industry Professional Activity Group. Additional information can be obtained from John A. McPherson, Underground Products Inc., 12801 Inkster St., Livonia, Mich.

May 9-10—

Engineering Institute on Product Development to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

May 10-12—

Symposium on Pulp and Paper Instrumentation to be held at the Northland Hotel, Green Bay, Wis. Sponsors are the Instrument Society of America and the Technical Association of the Pulp and Paper Industry. Further information is available from ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

May 19-20—

Design and Drafting Seminar, sponsored by the American Institute for Design and Drafting, to be held at Oklahoma State University, Stillwater, Okla. The program will cover such subjects as standards, training of design and drafting personnel, microfilming, reproductions, and photodrawings. Additional information is available from American Institute for Design and Drafting, 18465 James Couzens Highway, Detroit 35, Mich.

May 22-24—

National Symposium on Global Communications (Globecom V), to be held at the Sherman Hotel, Chicago. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further information can be obtained from IRE, 1 E. 79th St., New York 21, N. Y.

May 23-24—

Engineering Institute on Direct Energy-Conversion Systems to be held at the University of Wisconsin. Further information is available from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

May 25-26—

Engineering Institute on Plastic Films to be held at the University of Wisconsin. Additional information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

May 29-June 10—

Advanced Techniques of Programming Digital Systems-Mathematics, short course to be held at the University of California, Los Angeles. Course will deal with available techniques of programming and controlling digital systems, new research in the field of computer science, and new trends and problems arising both from new tendencies in the logical design of computer systems and from applications of digital systems to new fields. Further information is available from H. L. Tallman, Physical Sciences Extension, Room 6501 Engineering Bldg. II, University of California, Los Angeles 24, Calif.

June 8-9—

Engineering Institute on Practical Heat-Treating Fundamentals to be held at the University of Wisconsin. Further information can be obtained from Engineering Institutes, 3030 Stadium, University of Wisconsin Extension, Madison 6, Wis.

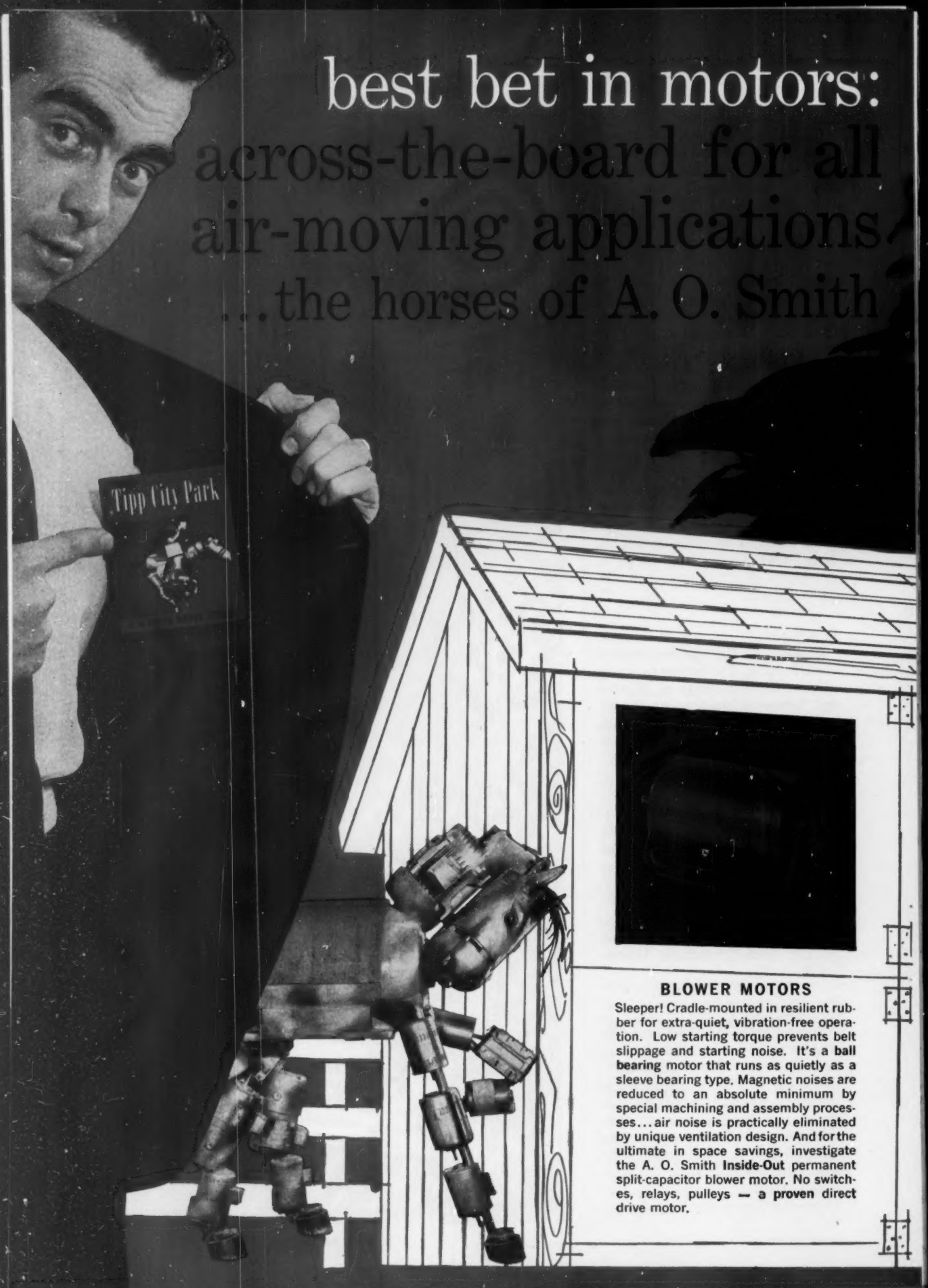
June 11-16—

Seminar on Electrical Contacts to be held at Pennsylvania State University. Theory and practice in electrical contacts, including static contacts and commutation, and arcs and arcing contacts, will be covered. Additional information is available from the Conference Center, Pennsylvania State University, University Park, Pa.

June 11-23—

Short Course on Solid-State Mechanics to be held at Pennsylvania State University. Major emphasis of the course will be on discussions of recently developed methods for evaluation and interpretation of stress-strain properties and the use of these procedures in design. Further information is available from the Conference Center, Pennsylvania State University, University Park, Pa.

Circle 221 on Page 19


best bet in motors:
across-the-board for all
air-moving applications
...the horses of A. O. Smith
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BLOWER MOTORS
Sleeper! Cradle-mounted in resilient rubber for extra-quiet, vibration-free operation. Low starting torque prevents belt slippage and starting noise. It's a ball bearing motor that runs as quietly as a sleeve bearing type. Magnetic noises are reduced to an absolute minimum by special machining and assembly processes... air noise is practically eliminated by unique ventilation design. And for the ultimate in space savings, investigate the A. O. Smith Inside-Out permanent split-capacitor blower motor. No switches, relays, pulleys — a proven direct drive motor.

PLAN ACROSS-THE-BOARD — You make your picks from a *complete* line of air conditioning and heating equipment motors—*blower* types . . . *inside-out* design . . . *hermetics* . . . *integrals* in a wide range of hp plus an exceptional range of modifications.

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And for the best tips in motors, send for our Tipp City Form. It contains track records on A. O. Smith's complete stable of fractional and integral hp favorites. Or get in touch with your nearby A. O. Smith motor man.

Through research ... a better way

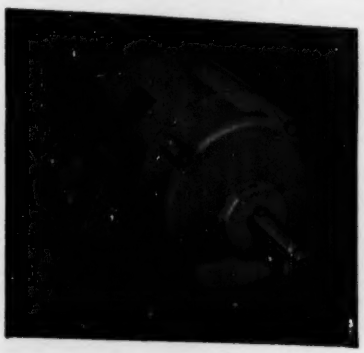
A.O.Smith

ELECTRIC MOTORS

Tipp City, Ohio

A. O. SMITH INTERNATIONAL, S. A.
Milwaukee 1, Wisconsin, U. S. A.

Circle 222 on Page 19



INTEGRALS

The workhorse of the A. O. Smith line. These open motors provide that extra amount of moisture protection. And you get quiet operation for critical noise areas along with a power reserve that pulls across adverse operating conditions. Rotors are pressure cast in one operation to provide an indestructible construction. Rotor and shaft assembly are dynamically balanced to minimize vibration. On models up through five hp single-phase, the capacitor is mounted inside the motor housing for space-saving installation, maximum protection and streamline appearance.

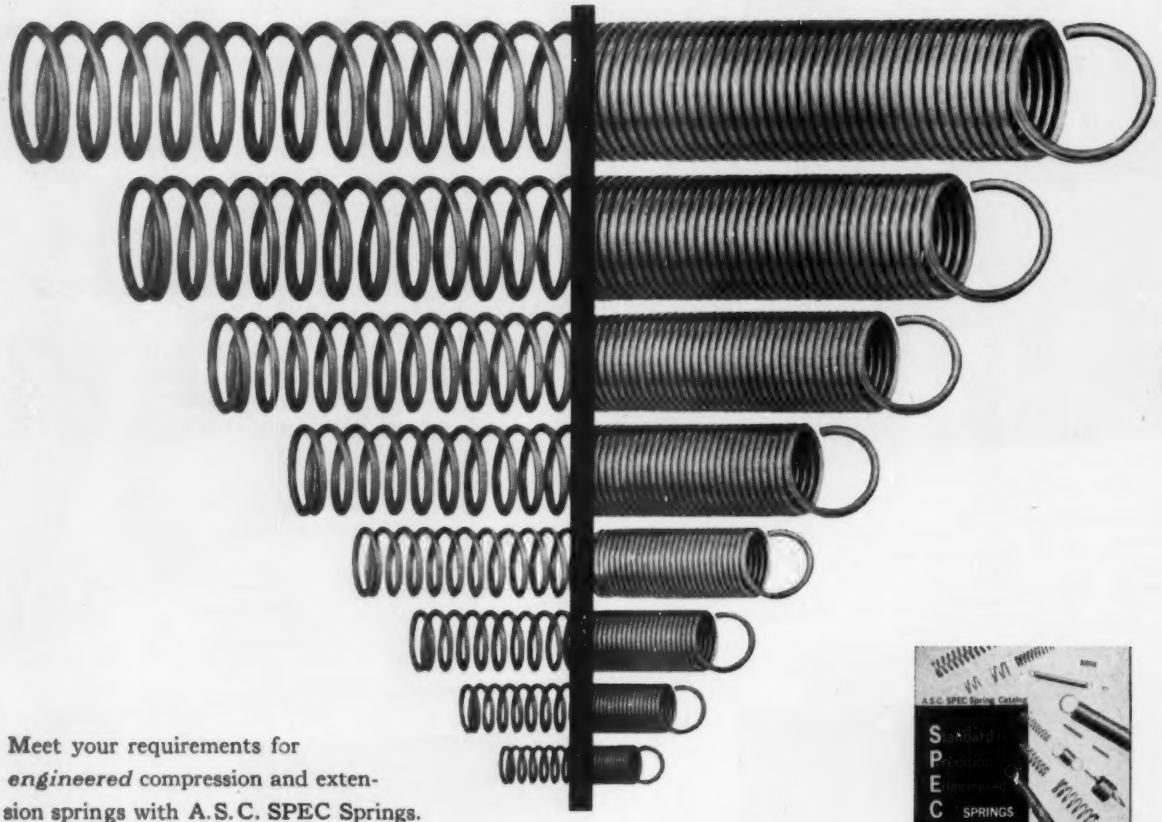
HERMETICS

A true thoroughbred! Rotor-stator assemblies are designed specifically for sealed compressors . . . quality-built to provide a reliable source of power for refrigeration or air conditioning, year-in and year-out. They're custom-built and dynamically-balanced for years of dependable, quiet, vibrationless service. What's more, each motor is manufactured under the strictest quality control . . . assembled and tested under controlled atmospheric conditions, ever-free of dirt and dust. Application-engineered in single-phase and polyphase, ¾ to 100 hp.

IN STOCK–for Fast Delivery–Hundreds of Sizes

A.S.C. SPEC Springs

Standard Precision Engineered Coil Springs



Meet your requirements for *engineered* compression and extension springs with A.S.C. SPEC Springs.

- Pinpoint your needs quickly.
- Especially convenient where quantities are moderate.
- No fuss or paperwork.
- No blueprints, drawings or samples needed.
- Match your requirements against the catalog list.
- Order by catalog number.
- Over 1,500 standard sizes in stock.

A.S.C. SPEC Springs are made from wire certified to military and aircraft specifications, in various lengths, diameters, rates, and loads up to 30 lb. They meet industry and military standards. Material is either music wire or stainless steel. All except smallest compression springs are squared and ground. Extension springs have regular loops. Other end treatment and loops optional.

Whether your need is immediate or future, write now for the A.S.C. SPEC Spring catalog and price list. Keep it handy as a time-saving, useful spring service.

6107

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
F. N. Manross and Sons Division, Bristol, Conn.
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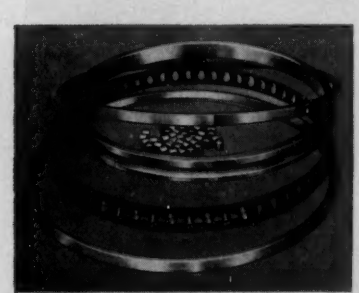
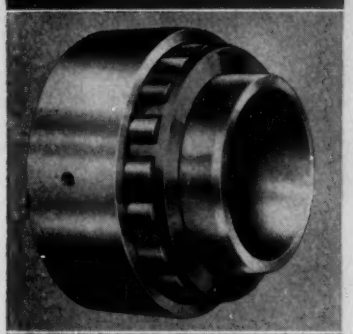
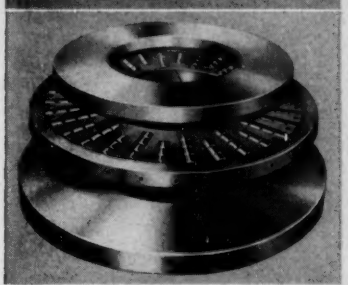
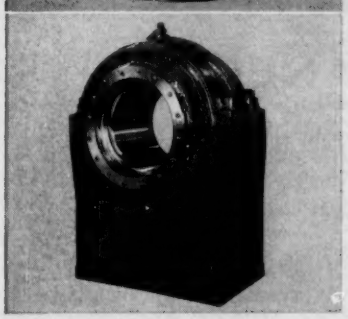
DESIGN ELEMENTS... *for Improved Product Performance*









MESSINGER "X" BEARINGS

Versatility and enduring accuracy are two important advantages of the Patented "X" Bearing. Takes thrust load in either direction, with radial load and overturning moment—if necessary, all at one time. Sizes range upward from 4.000" bore. Typical applications: Gun turrets; radar screens; work, press, calendar and suction rolls; propellers; boring mill tables; rock crushers; glass grinding machines.

MESSINGER RADIAL ROLLER BEARINGS

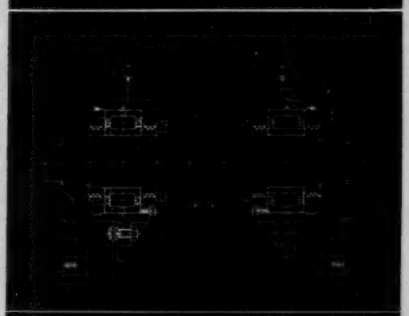
Designed to carry extremely heavy loads in less space with less weight. Available in the following types: Plain; Self-Aligning With Adapter; Self-Aligning Without Adapter; Combination Radial and Thrust Bearing; Combination Radial and "X" Bearing. Standard sizes from 4" to 60" bore. Typical applications: Straightener, Back-up, Press and Work Rolls; Drive Shafts of all kinds; Beaters; Embossers; Rudder Shafts; Heavy-duty Cranes.

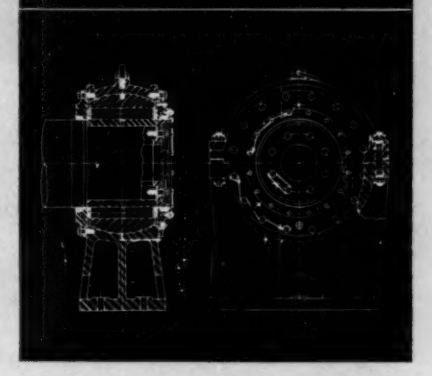
MESSINGER THRUST ROLLER BEARINGS

Designed to carry heavy thrust loads—3 to 4 times the load of same size ball bearing. SINGLE-ACTING TYPE may be positioned horizontally or vertically. DOUBLE-ACTING TYPE carries thrust load in two directions. SELF-ALIGNING TYPE provides constant correction for misalignment. Standard sizes from 3" to 95" bore. Typical applications: Steel and paper mill equipment; large cranes; rock crushers; dam gates; grinding machines; vertical shaft motors, generators, pumps, heaters, etc.

MESSINGER PILLOW BLOCKS

Features include exceptional compactness; efficient oil seals; automatic flood oiling; and use of self-aligning bearings to compensate for misalignment of support. Roller bearings may be plain radial or combination radial and thrust, to handle any type of loading. Can be designed and built to accommodate any required shaft size. Wide range of applications including heavy-duty "hinges" for drawbridges with shaft diameters 20" and larger.





The MESSINGER bearings described above are merely representative of the many types available for every kind of machinery and equipment. If bearings are called for, early consultation with our engineer-representatives could be helpful.

MESSINGER BEARINGS, Inc.

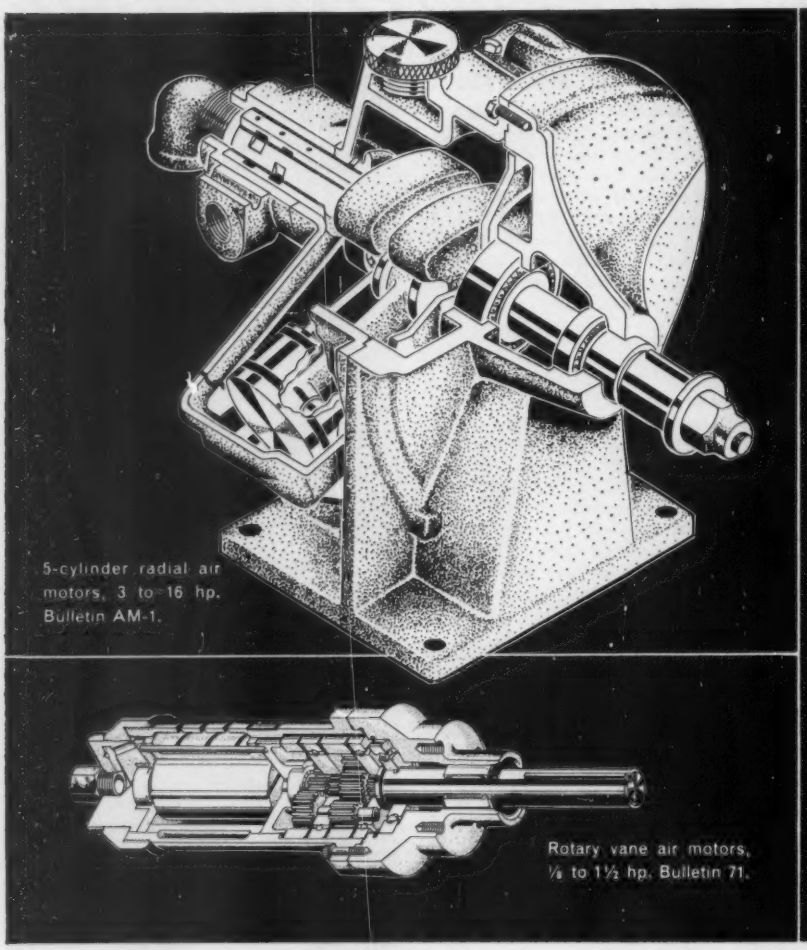
ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"

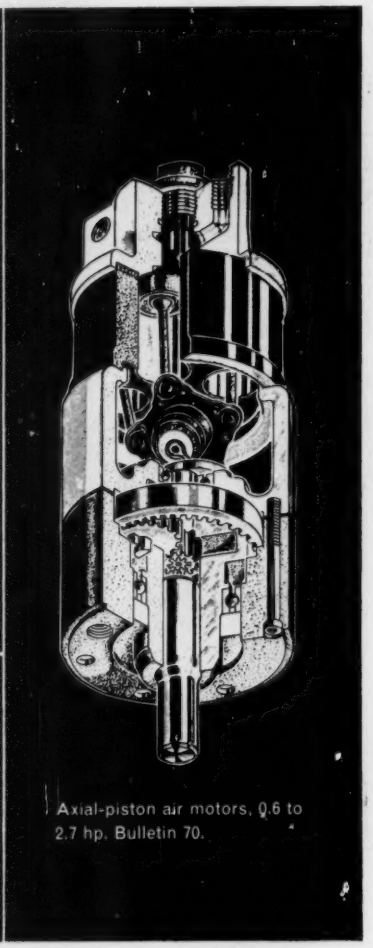
Circle 224 on Page 19

When you analyze power values, look to air power for new ideas



5-cylinder radial air motors, 3 to 16 hp. Bulletin AM-1.

Rotary vane air motors, ⅛ to 1½ hp. Bulletin 71.



Axial-piston air motors, 0.6 to 2.7 hp. Bulletin 70.

MEET ALL THESE POWER NEEDS

- High starting torque
- Reversibility without power loss
- Variable speed, easily controlled
- Cool operation
- Instantaneous starts and stops
- Consistent torque output
- Spark-resistant characteristics
- Thrust or axial spindle loads
- Enclosed construction
- Output from ⅛ to 16 hp

Your Gardner-Denver specialist will be glad to consult with you in putting air power to work in your new designs.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

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Circle 225 on Page 19

SPECTRO-GRAPHICALLY ANALYZED

Every sheet, coil or tubing shipment of Quaker State aluminum is now certified in writing. It's your assurance that *your* order has passed our rigid standards of quality control to meet your exacting specifications.

SPECTROGRAPHICALLY ANALYZED
Our quantometer spectro-chemically analyzes every rolling ingot cast at Quaker State. It determines within a tenth of one percent the amount of each alloying element. Wet Chemical Analysis will be made by our chemists when requested.

QS M

HOWE SOUND COMPANY

QUAKER STATE METALS COMPANY

Lancaster, Pennsylvania Circle 226 on Page 19

A DIVISION of HOWE SOUND COMPANY

Mill Producers of Aluminum Sheet, Coil, Tubing and Extrusions

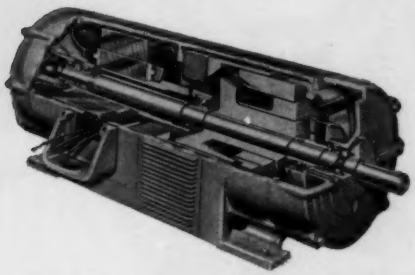
What do you need in an adjustable speed drive?

Better Regulation!

Compactness!

Less Maintenance!

7½-hp Ajusto-Spede Drive



Common motor-drive housing for units up to 7½ hp saves space — can be foot or flange mounted. Larger sizes up to 100 hp with individual motor and drive housings mounted integrally.

NEW design news from Louis Allis

...The Louis Allis AJUSTO-SPEDE® drive is more compact, precise, and trouble-free

Here's an adjustable speed drive that allows *truly precise* machine operation. Speed regulation is automatic and stepless — results in faster, more efficient production at lower cost, with less waste, and minimum wear on equipment.

These and other benefits are yours when you use the improved Louis Allis Ajusto-Spede drive. For example, it can be set before or during operation to deliver any desired speed within its range. Its *exclusive* tachometer feedback circuit monitors the output speed and *automatically corrects speed and holds it* regardless of load changes.

This improved drive requires minimum maintenance. Its stationary field has no brushes, commutators, or slip rings to cause trouble. The source of power is an equally trouble-free standard a-c squirrel cage motor. The cast-iron housing keeps out dirt, chips, and moisture — resists corrosion.

The compact Ajusto-Spede also saves space. Integrally-mounted motor and drive simplify handling — can be easily adapted for installation on new or existing machines. Controls can be mounted at the machine or any other convenient position.

The Louis Allis Ajusto-Spede drive is the practical solution to almost every application that requires dependable, easily controlled adjustable speed. It is the answer to precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and other equipment. Contact your Louis Allis District Office for information and application help. Or write for bulletins 2750 and 2800 — The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

® Ajusto-Spede is a registered trademark of the Eaton Mfg. Co.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

ASD-127

Circle 227 on Page 19

From microfilm to an 18"x 24" print ...in seconds and on ordinary paper!

You can have a dry, positive, 18"x24" engineering print in seconds and on ordinary paper with the new XeroX® Copyflo® 1824 printer.

This remarkable machine, which requires no exposure settings or other adjustments, reproduces from a microfilm aperture card, making 18"x24" prints—or smaller—at extremely low cost. It also copies onto vellum or offset paper masters.

Operation is automatic. Prints ready for immediate use emerge as fast as four a minute.

The quality of reproduction is superb. Images are sharp black-on-white and won't rub off. There is no odor, no waste, and the finished print may be written on with pen or pencil.

Regardless of your engineering-drawing-reproduction needs, you can now enjoy the tremendous savings in time, money, space, and materials of your own unitized microfilm system.

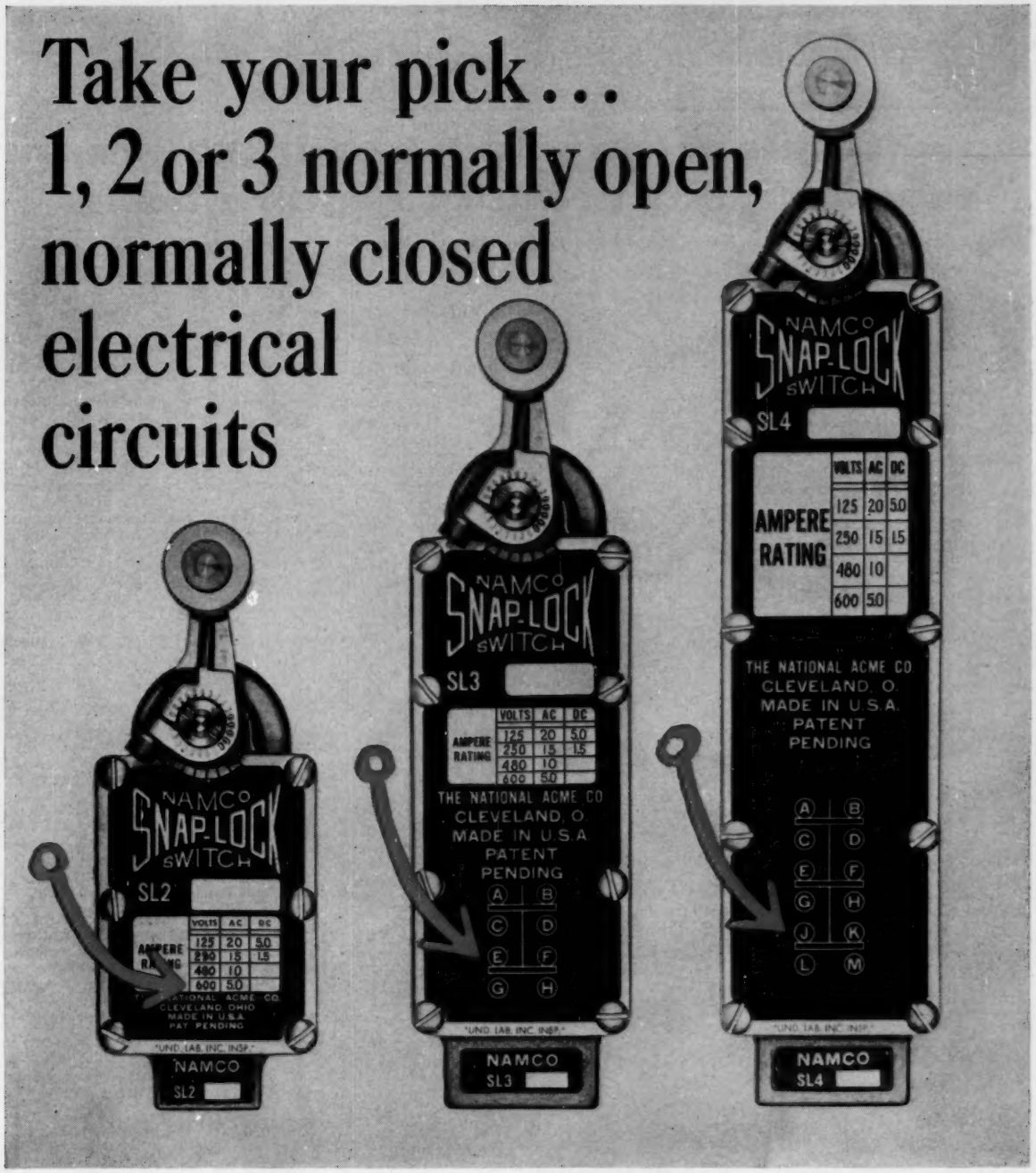
Formerly, such economies required a substantial reproduction need. Today, however, the Copyflo 1824 printer offers the same proportionate benefit to small-volume users as to large. No need now for vast files of engineering drawings. Microfilm aperture cards require only a fraction of the storage space required for other reproducibles. No more costly waiting for prints, which—made by a Copyflo 1824 printer—are so inexpensive your engineers can discard them after use.

Write today for our free 1824 booklet giving the full benefits you can expect from a Copyflo 1824 printer. HALOID XEROX INC., 61-171X, Haloid St., Rochester 3, N.Y. Branch offices in principal U.S. and Canadian cities. Overseas: Rank-Xerox Ltd., London.

HALOID XEROX®

Circle 228 on Page 19

Take your pick... 1, 2 or 3 normally open, normally closed electrical circuits



What does your limit switching application call for . . . one, two or three normally open, normally closed electrical circuits? Whatever it is, one of these National Acme SL "Machine Life" Limit Switches . . . the SL2, the SL3 or the SL4 . . . will meet your precise requirement. And, every SL offers . . . a variety of cam arrangements for extreme operating flexibility . . . ample overtravel (67°) and by-pass (90°) . . . light operating pressure (10½ lbs. at 1½" radius). Also available . . . the SLS 2, 3 or 4 featuring "hi-shock" sliding contacts; particularly suitable for drop forge, punch press and other heavy equipment application. Call, write or wire for complete information.

National Acme

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.

OEM Guide to Electric Heaters

How to select the exact heating element to meet your product requirements

Here's condensed information from General Electric to help you get the most economical heater for your products.

CARTRIDGE HEATERS

• **Applications**—Efficient, self-contained heaters, for use singly to provide a "spot" of heat, or grouped to heat larger surfaces. Perfected for use in process machinery and for localized heating requiring close thermal control: dies, platens, molds, extrusion and injection barrels, gluepots, compound pots.

• **Features**—Durable nickel-chromium resistance wire packed in insulation and sheathed in metal tube.

• **Ratings**—30 to 2800 watts—Sheath temperatures: brass (750F); nickel-silver (1000F); chrome-steel (1200F)—Over-all lengths: 1½ in. to 2 ft.—Diameters: ⅜ in. to 1.293 in.—115v to 230v.

IMMERSION HEATERS

• **Applications**—Offer clean, economical method of heating various liquids in tanks, kettles, jackets and other containers. Suitable for immersion in water, oil, alkaline solutions, nickel, copper, chrome, plating solutions, mild sulphuric acid baths and salt baths.

• **Features**—Long life—Easily installed—Easily controlled—Sealed terminals—Excellent insulation and heat conduction.

• **Ratings**—Both through-the-side and over-the-side models available—Sheath materials: copper, nickel-silver, stainless steel, Inconel and lead—115v to 230v—Wide variety of models from 650 to 10,000 watts.

FIN TUBULAR HEATERS

• **Applications**—Especially suited to forced-convection air heating applications, such as air ducts with forced-air circulation, blower-type electric unit heaters, car heaters, recirculating ovens, industrial processes requiring heated air blasts for drying, baking, testing or pre-heating.

• **Features**—Large radiating surface per unit length—Fins sturdily attached by brazing—Quick heat transfer—Nonoxidizing rust-resistant finish—Durable construction.

• **Ratings**—Wide variety of shapes available—Sheath temperature: steel (850F)—Watts: up to 100 per linear inch.

TUBULAR HEATERS

Applications—Applicable to practically every low-temperature (1500F or lower) requirement, whether heating liquids, air, soft metals, or metal surfaces. Typical applications: ovens, ducts, platens, pipes, space heaters.

• **Features**—High-quality resistance wire, insulated in metal tubing—Heaters bent to conform to almost any shape, cast into metal, located in drilled holes, grooves, or spaced away from surfaces.

• **Ratings**—Standard ratings, 500 to 5000 watts; special ratings available—Sheath materials: steel (750F); nickel-silver (1000F); stainless and Inconel (1500F); copper (212F in water).

STRIP HEATERS

• **Applications**—Designed for direct clamping to surfaces. Typical applications: process machinery, drying ovens, matrix scorchers, warming tables, glue tables, water baths, drying cabinets, pipelines, incubators, valve and pump houses, telephone switchboards, roll heating, packaging machinery.

• **Features**—Uniform heat distribution—Corrosion-resistant sheath materials—Easy to install—Moderate cost—Uniformity.

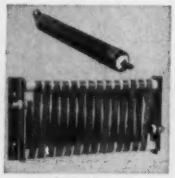
• **Ratings**—Provided with offset terminals at one end or terminals at each end—Sheath materials: Aluminized-steel (1000F); Chromized-steel (1200F).

METAL-MELTING HEATERS AND POTS

• **Applications**—Feature cast-in immersion heaters for melting lead, babbitt, tin, solder, type metal and similar metals up to 950F. Applications: dip soldering of subassemblies, railway and repair shops, electric service shops, printing plants, manufacturing plants, remelting metals.

• **Features**—Heat generated right in metal for quick heating, low radiation losses—Heater easily replaced without interrupting production—Reliable, safe, economical—Can be tied in with automatic temperature control.

• **Ratings**—Standard melting pots—Wt. 50 to 2000 lbs—Watts: 750 to 30,000.

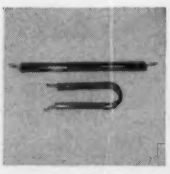


OVEN HEATERS

• **Applications**—Designed for such applications as baking, japan, foundry cores, drying, low-temperature drawing ovens, and for general air heating applications in which there is free movement of air by convection. Heaters used in recirculating type ovens for core baking, paint drying, tempering, air heating in ducts, placement inside oven.

• **Features**—Easily mounted on side walls of oven or in ducts—Wide range in heater ratings and combinations of heaters.

• **Ratings**—Temperatures: Two models available: 750F–1000F, and up to 1200F.



VANE-TYPE HEATERS

• **Applications**—Used for air and surface heating applications: baseboard heaters, pipe heating, platen heating, valve and pump heating, drying cabinets and ovens, process machinery, compound tanks.

• **Features**—Rugged tubular construction resists mechanical shock and vibration—Large, 1¾ in. wide radiating surface—Low heat density: 25 watts per linear in. of vane; 14.3 watts per sq. in. of heater surface—Can be easily formed—Convenient mounting holes.

• **Ratings**—Variety of models from 500 to 2500 watts—115 to 230 volts—Over-all lengths: 24 to 104 inches—Maximum operating temperature 750F.

FREE New Catalog of General Electric Calrod* Industrial Heaters and Devices

• **Complete information** on these and many other G-E heaters and devices and control.

• **Easy-to-use application data**—New charts, tables, and guides make it easy to select just the right product for any application.

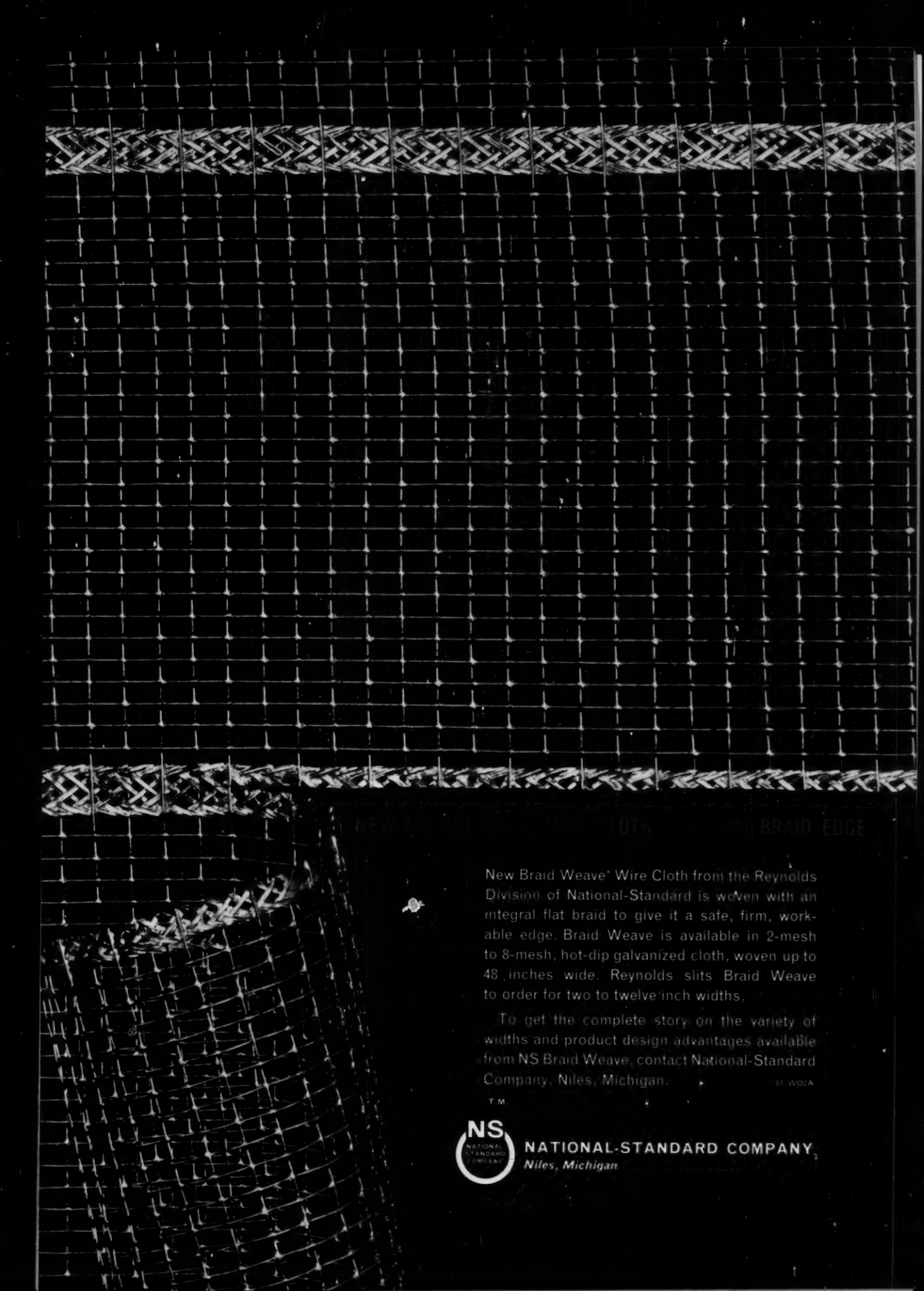
For your new catalog, write today to Section 757-02, General Electric Company, Schenectady 5, N. Y. Ask for GEC-1005.

*Reg. Trade-mark of General Electric Co.

GENERAL ELECTRIC

Circle 230 on Page 19

Circle 231 on Page 19→



New Braid Weave* Wire Cloth from the Reynolds Division of National-Standard is woven with an integral flat braid to give it a safe, firm, workable edge. Braid Weave is available in 2-mesh to 8-mesh, hot-dip galvanized cloth, woven up to 48 inches wide. Reynolds slits Braid Weave to order for two to twelve inch widths.

To get the complete story on the variety of widths and product design advantages available from NS Braid Weave, contact National-Standard Company, Niles, Michigan.

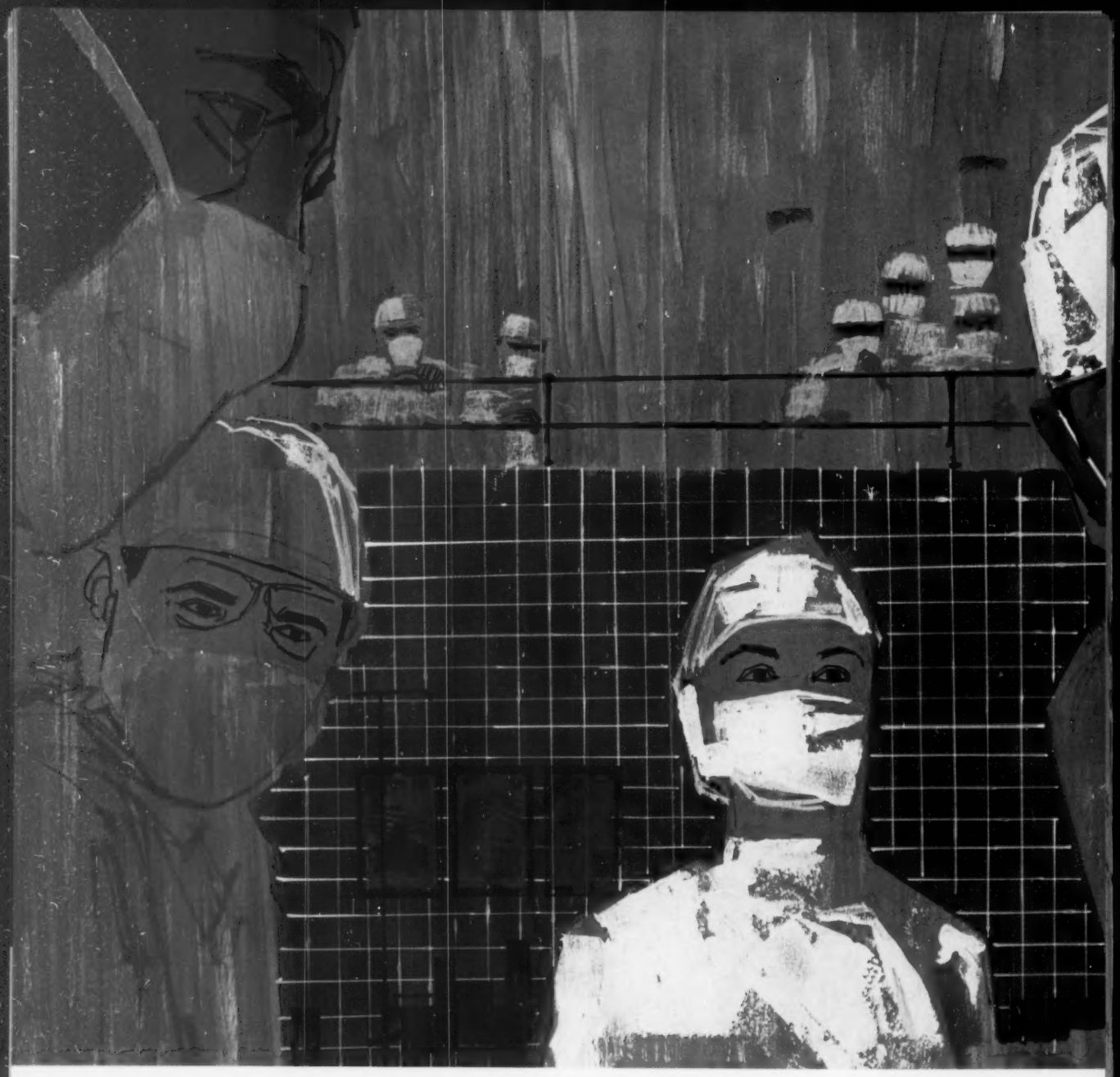
BT WOZA

T.M.

NS

NATIONAL-STANDARD COMPANY

Niles, Michigan



NS SPECIAL WIRE TRANSMITS

Doctors are saving more lives today in heart surgery cases through the transmission of carefully timed electrical pulses into the heart. Many patients suffering from lost heartbeat due to surgery or other causes have been restored to active life through such heart stimulation.

A LEADING MEDICAL INSTRUMENT COMPANY developed a pocket-size electronic package to generate the electrical impulse, which is transmitted to the heart through the jugular vein by a tiny stainless steel braided wire.

In their search for the right conductor to carry the electric pulses to the heart, researchers came to National-Standard for help in developing a wire flexible enough to follow the intricate path of the circulatory system, while, at the same time, soft enough to avoid damaging the blood vessels or the heart itself. In addition, the wire had to be very thin, strong enough to withstand the constant flexing of the heart, and with just the proper electrical characteristics.

NATIONAL-STANDARD ENGINEERS developed a braid of 16 wires, each .0036″ diameter, or about the thickness of human hair. Using type 302 stainless

SPARK OF LIFE

steel wire, NS engineers produced a braided wire with high tensile strength, good resistance to fracture, good conductivity and flexibility just right for the delicate application.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

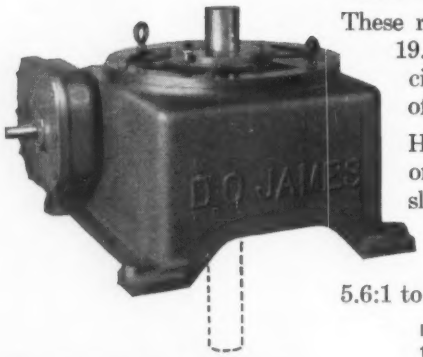
NS SPECIAL WIRE transmits spark of life from transistorized, battery-powered package, through jugular vein, to the heart. Carefully timed electrical pulses train tired hearts to beat normally again.

D. O. JAMES SPEED REDUCER REDUCTION DATA

for high efficiency

at higher reduction ratios, use helical worm reducers

D. O. James helical worm gear speed reducers include a conventional worm and gear plus an auxiliary set of high-efficiency helical gears on the input shaft.

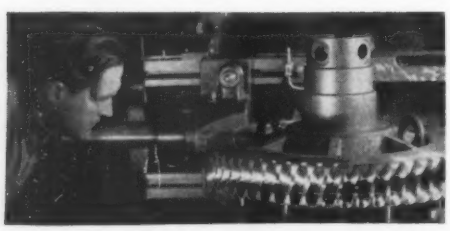


These reducers are built in 13 sizes, .13 to 150.0 hp, 19.2:1 to 400:1 ratios. At ratios above 60:1, efficiencies range as much as 15% higher than those of straight worm reducers.

Horizontal-drive types are available with right- or left-hand assembly, vertical types with the slow-speed shaft extending upward or downward.

For complete data on these and other types of worm gear reducers from .04 to 206 hp, 5.6:1 to 10,000:1 ratios, ask for Catalog No. 45-D.

D. O. JAMES GEAR MANUFACTURING CO.
1140 West Monroe Street, Chicago 7, Illinois
Since 1888, every type of gear and gear speed reducer



D.O.James

...where you always get good gearing

Circle 232 on Page 19

Circle 233 on Page 19→

You get more value for the same dollar— in the NEW Bulletin 709 line of starters!

SIZE 00

SIZE 5

Note the compactness of both the smallest and largest starter in the new Bulletin 709 line. Ratings up to 100 hp, 220 v; 200 hp, 440-550 v.

This new line of Allen-Bradley motor control will change every idea you have had about starter size, performance, and life. The small size—especially in the higher ratings—is startling. Yet rating for rating the operating life and reliability have been increased many times. Built into each of the seven sizes of this new Allen-Bradley line is an ability to interrupt tremendous currents and to operate year in and year out for many millions of operations without trouble or maintenance.

The new Bulletin 709 starters are just as advanced in appearance as they are in performance. All seven sizes have an aristocratic styling and a distinctive family likeness. Brooks Stevens, famous industrial designer, has given the enclosures such an attractive, modern style that these new starters will prove a distinct sales asset on any machine or installation.

Why not write today for more information on this revolutionary new line of Allen-Bradley Bulletin 709 *quality* across-the-line motor starters?

10-61-RM

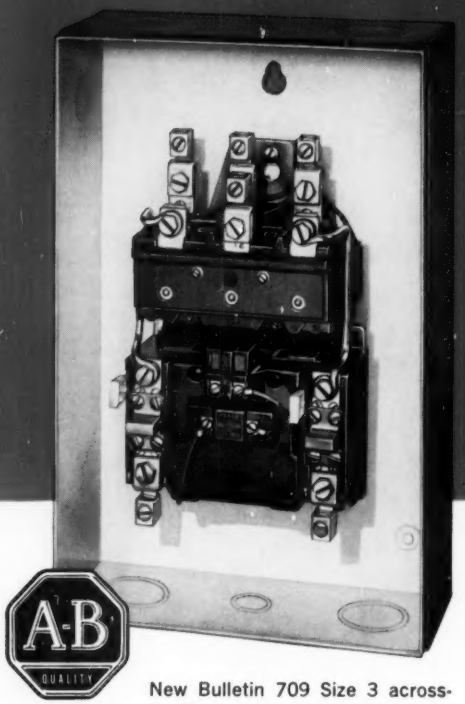
ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

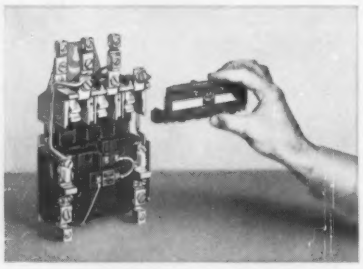
QUALITY MOTOR CONTROL

Features of the NEW Allen-Bradley starter line that are of value to you!

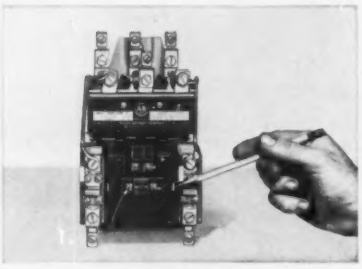


New Bulletin 709 Size 3 across-the-line motor starter. Note the generous space for wiring, accessible terminals, and white interior.

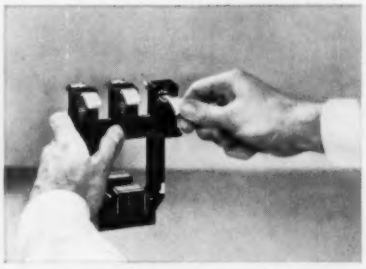
Every detail of the new Allen-Bradley motor starters has been designed to help make this the best line of motor control on the market. Remarkably small in size, each starter is a giant in performance. Being light in weight, these starters are easy to handle and a cinch to install. The generous wiring space, full front wiring, white interiors, and convenient knockouts make installation easy. The enclosure cover is firmly held with a quarter-turn fastener. All installation, inspection, and maintenance operations can be handled from the front—as shown in the illustrations below—without the use of special tools.



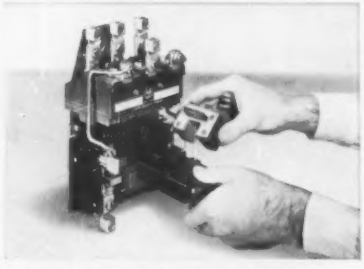
QUICK, EASY CONTACT INSPECTION—When the arc hood front cover is removed by loosening two captive screws, contacts are plainly visible from the front.



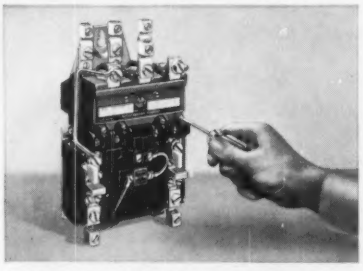
CONTACT POSITION INDICATED—Two slots in the coil cover show the position of the movable contact support—tell whether contacts are "closed" or "open."



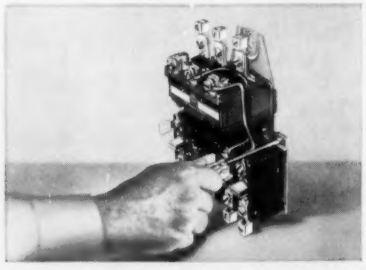
CONTACTS EASILY REPLACED—Depress the spring slightly, and the movable contacts can be lifted out of the molded support and the new contacts slipped in.



COIL EASILY CHANGED—When the coil cover is removed, coil and magnet yoke can be lifted out from the front. They are impossible to replace incorrectly.



AUXILIARY CONTACTS EASILY ADDED to the front of the starter. Two extra auxiliaries can be added to Sizes 0, 1, and 2 starters, and four, to Sizes 3, 4, and 5.



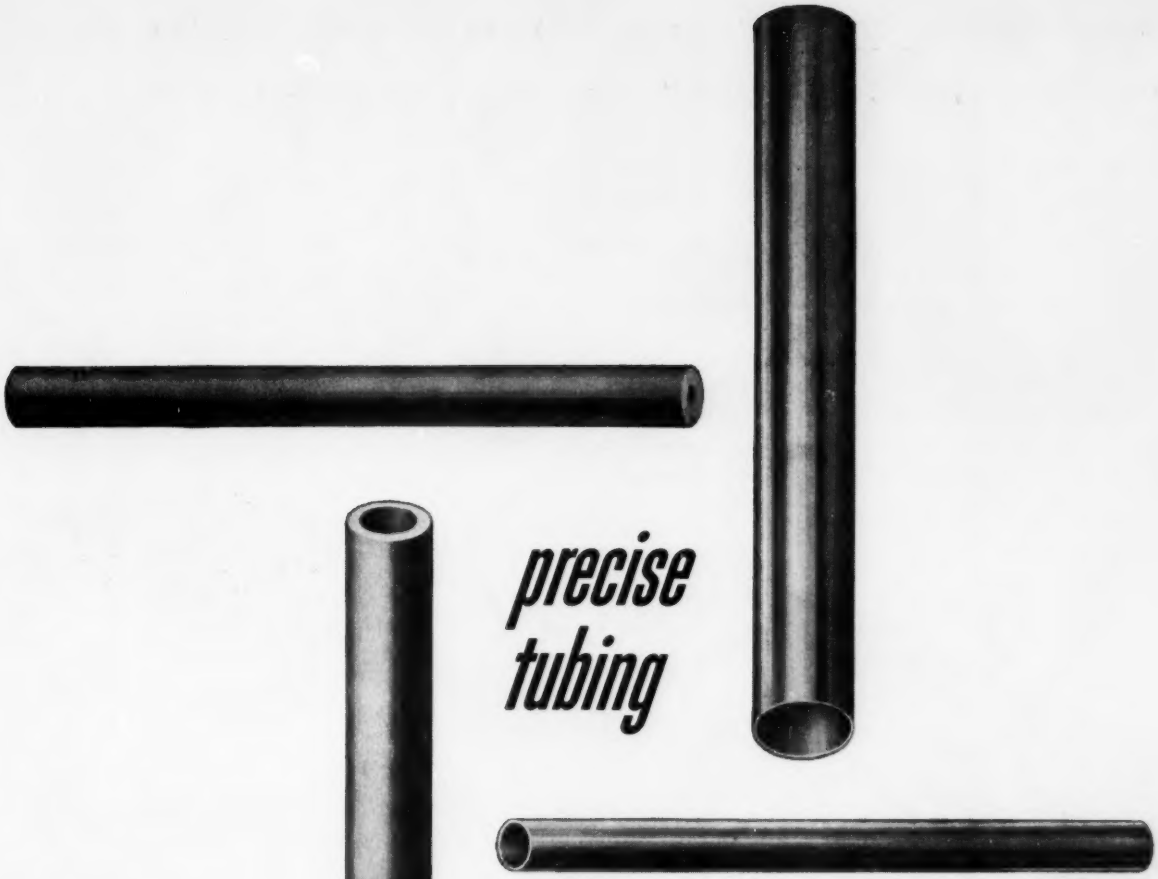
A THIRD OVERLOAD RELAY CAN BE EASILY ADDED in the field, from the front of the starter. And the only tool needed is a common screwdriver.

ALLEN-BRADLEY

Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

QUALITY MOTOR CONTROL



precise tubing

In a wide selection of seamless and welded and drawn up to 1" O. D.

- Stainless Steel . . . Nickel . . . Nickel Alloys . . . Super and Exotic Alloys
- Glass-to-Metal Sealing Alloys
- Clad Metals and
- Composite Wires . . . Base and Precious Metals

Write for Bulletin No. 12

BISHOP

Tubular Products Division **J. BISHOP & CO.** *platinum works*

75 KING STREET, MALVERN, PENNA.

A JOHNSON MATTHEY ASSOCIATE

"METALS FOR PRECISION AND PERFORMANCE"

OFFICES: NEW YORK • CHICAGO • ATLANTA • HOUSTON • LOS ANGELES

←Circle 233 on Page 19

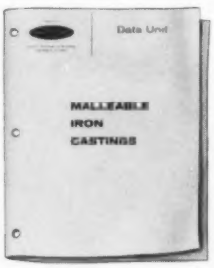
Circle 234 on Page 19

New Cars and Trucks Use More Malleable For Better Performance...Lower Cost

As the automotive industry steps up its drive to pack greater performance into lighter weight vehicles and still hold costs in line, the demand for Malleable iron castings continues to increase. Noted for their strength, toughness, machinability and economy, Malleables are used as key components in every make and type of vehicle.

Matching each new advance in automotive technology, Malleable is now available in a broad range of properties, including tensile strengths from 50,000 to 120,000 psi!

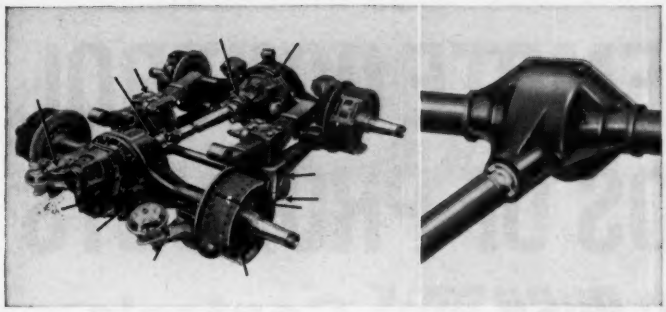
Find out now how much Malleable castings can improve your products. Contact any company that displays this symbol —



For Free Literature on advantages of Malleable iron castings, with examples from the automotive industry, ask any member company for Data Unit No. 113, or write to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

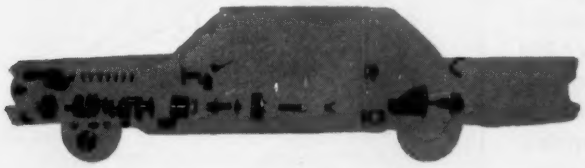
MEMBER
MALLEABLE
CASTINGS COUNCIL

Testifying to Malleable's outstanding ability, pearlitic Malleable iron crankshafts are now used in both cars and trucks, like this new heavy-duty highway hauler. Pearlitic Malleable was chosen for its high strength, wear resistance, damping capacity and machinability . . . Malleable is the most machinable of all ferrous metals of similar properties.



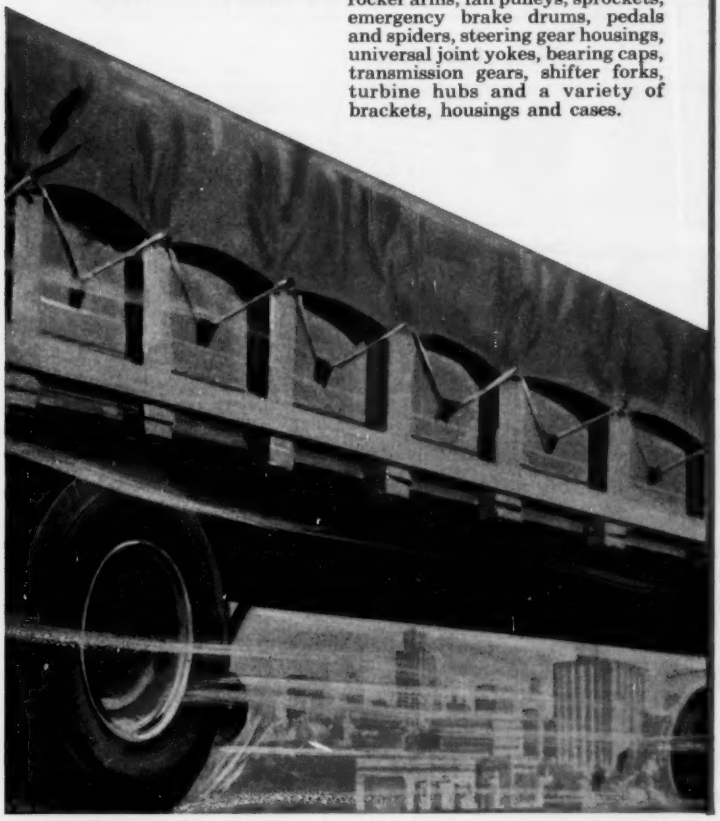
From the smallest cars to the largest trucks, all American vehicles rely on Malleable for a range of uses. In this tandem axle, for example, a total of 36 parts is Malleable.

Malleable differential carriers form the backbone of the rear axles on many new compact cars, as shown at the right above. Tubular steel extensions are pressed into the Malleable housing where they are "puddle" welded. Decisive factors in Malleable's selection were strength, economy, ease of machining and ability to be produced in a design that required a minimum of tooling expense.



The increasing conversion from other materials to Malleable castings for all kinds of parts from crankshafts to door hinges is adding momentum to the automotive industry's steadily increasing use of Malleable.

Among the many Malleable iron castings in this composite car are torsion bar arms and brackets, rocker arms, fan pulleys, sprockets, emergency brake drums, pedals and spiders, steering gear housings, universal joint yokes, bearing caps, transmission gears, shifter forks, turbine hubs and a variety of brackets, housings and cases.



For Quality and Economy Use

MALLEABLE

For Service Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Iron Works, Moline
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

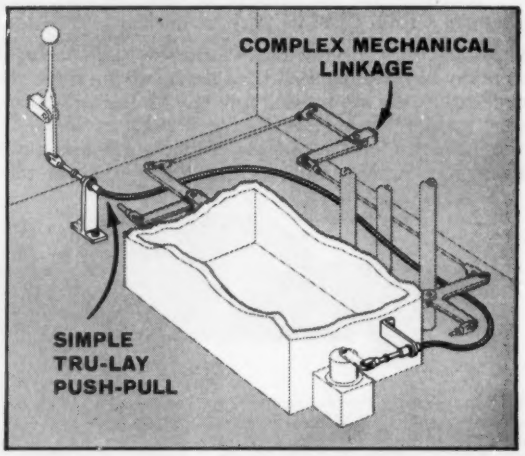
These companies are members of the Malleable Castings Council

Circle 235 on Page 19

ACCURATE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

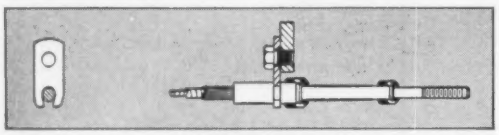
— — with Tru-Lay *PUSH*-PULL Controls

If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over short or long distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, vibration rattles and lost accuracy.

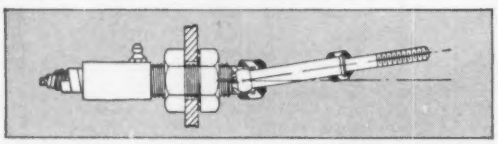


THESE FEATURES HELP SOLVE DESIGN PROBLEMS

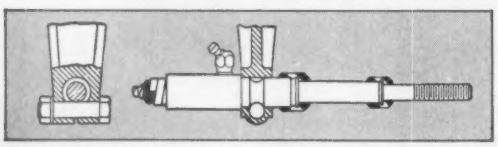
Anchorages



Clip anchorage • a simple clip for light loads

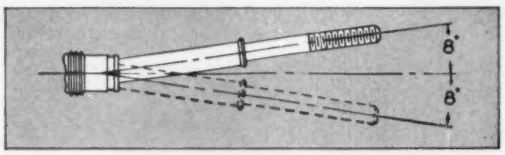


Bulkhead anchorage • for heavy-duty installations



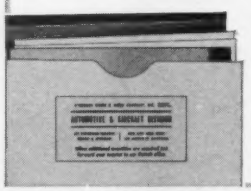
Machined bracket anchorage • can be furnished for mounting any PUSH-PULL cable at the swivel terminal

Swivel Action



Standard assemblies have end fittings with a swivel movement of ± 8° to compensate for misalignment and rise or fall of lever arms. Swivel joints, and the sliding ends, are sealed against dirt and moisture.

PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY, IMPROVE DESIGN



• Write for your PUSH-PULL Data File. It contains a complete set of engineering bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages.

ACCO

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.

Designing a machine?

Let your local Gates Engineer Prove Super HC Drives save space, weight, money

If you are designing a new machine or redesigning one for better performance, your local Gates Field Engineer will be glad to help you. He can show you how to take full advantage of the many opportunities offered by Gates Super HC High Capacity Drives.

Ask him to design a drive for your machine two ways: a conventional V-belt drive and a new Gates Super HC High Capacity V-Belt Drive. A quick comparison will show you many of the important savings provided by the new Gates drive.

Manufacturers everywhere have standardized upon the Gates Super HC V-Belt Drive—industry's first and most advanced high capacity drive. It is your best assurance that your power transmission unit will not soon become obsolete.

Your local Gates Field Engineer is an experienced, fully-qualified drive design expert. Contact him for drive design help.

The Gates Rubber Company
Denver, Colorado

Gates Super HC Drives give you these benefits:

- Handles up to 3 times more horsepower than conventional V-belts in the same space.
- Saves up to 50% in drive space.
- Reduces drive weight 20% and more.
- Cuts drive costs as much as 20%.
- Reduces bearing load, increasing bearing life.
- Guards and machine housings can be smaller, lighter weight.
- Belt speed up to 6000 ft/min possible without dynamic balancing.
- Less costly, higher speed motors can often be used.

BP-11

Exclusive design features include:

precisely engineered arched top, concave sidewalls, Flex-Weave cover, super strength tensile construction.

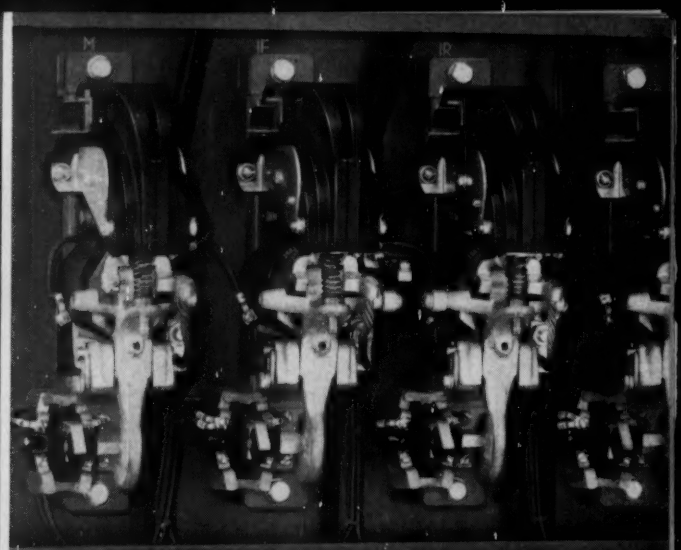
Building the future on 50 years of progress

Gates

Gates Super HC V-Belt Drives

Circle 237 on Page 19

NEW! **COMPACT 300 VOLT CONTROL RELAY** Space-savingest relay ever! So reliable it is permanently enclosed.



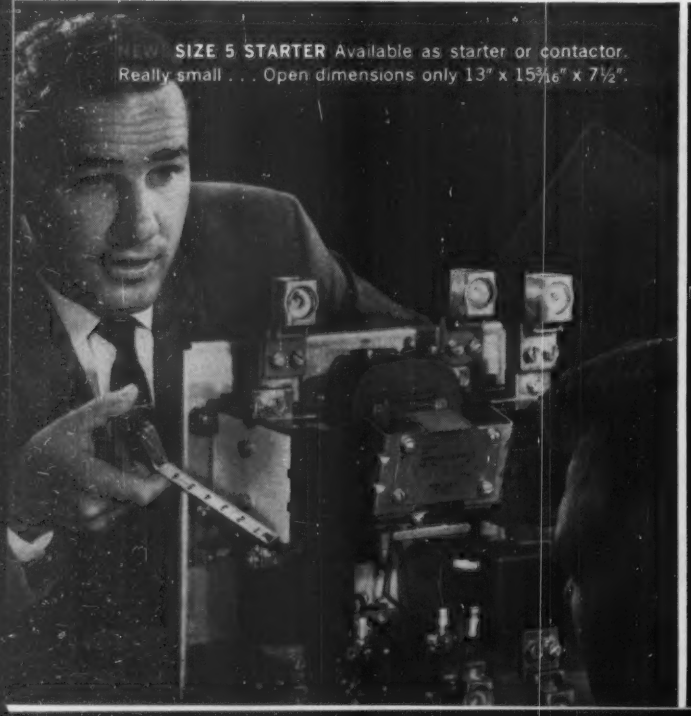
NEW! **D-C UNITIZED CONTACTORS.** For steel or slate panels, front or back wiring. Six sizes 25 to 600 amperes.

New from Cutler-Hammer

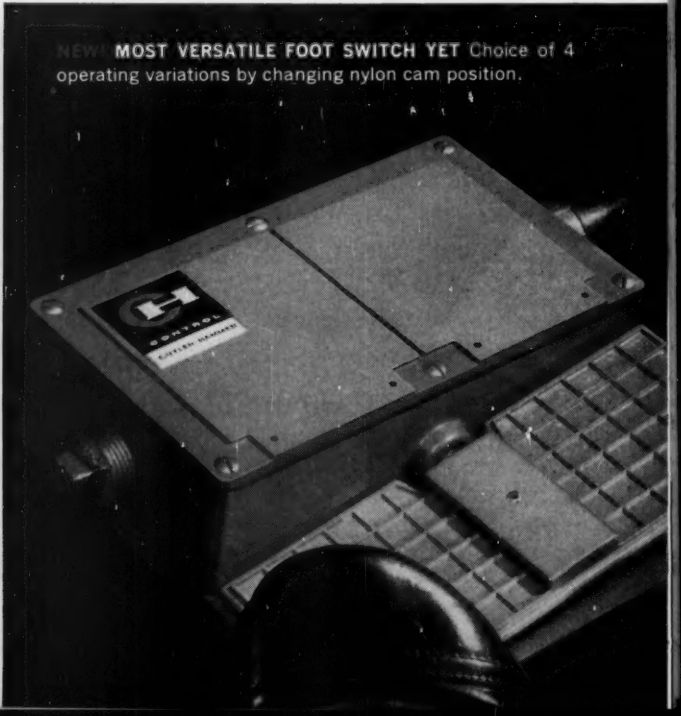
New products, new ideas to help your business now

The air is charged with new ideas at Cutler-Hammer . . . ideas and products resulting from our new production facilities, new engineering talent, new research programs, and most important of all—*a new desire to serve you better in the sixties.* Evidence of this vitality and what it can mean to you are these eight typical new products.

You can expect more news from Cutler-Hammer around the calendar. Give your Cutler-Hammer sales office or distributor a call. They're all charged up too—anxious to tell you more about *what's new at Cutler-Hammer.* For descriptive literature on any of these products, write Cutler-Hammer or call your nearest Cutler-Hammer distributor.

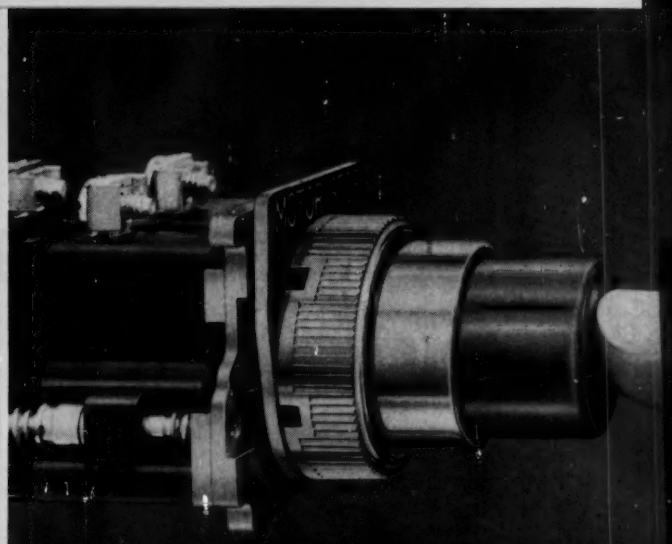


NEW! **SIZE 5 STARTER** Available as starter or contactor. Really small . . . Open dimensions only 13" x 15 5/16" x 7½".



NEW! **MOST VERSATILE FOOT SWITCH YET** Choice of 4 operating variations by changing nylon cam position.

UNITROL DESIGN in choice of three depths (20", 15", 12") gives more flexible motor control center.



ILLUMINATED PUSHBUTTONS Newest addition to this versatile oiltight line. Dozens of types, many colors.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

CONTROL

Circle 238 on Page 19

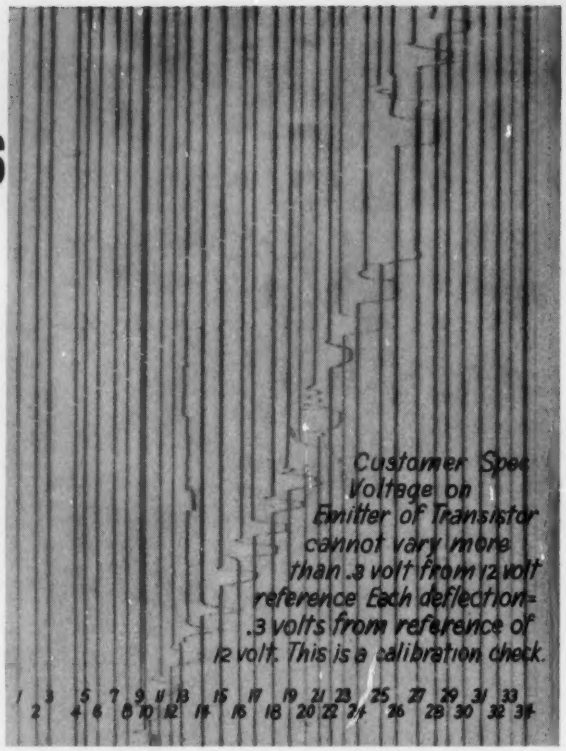
SPACE-SAVING 00 STARTER Takes 20% less space, costs 18% less than Size 0.

MOST RELIABLE LIMIT SWITCH EVER This oiltight switch outlasts others by far. Many operator options.

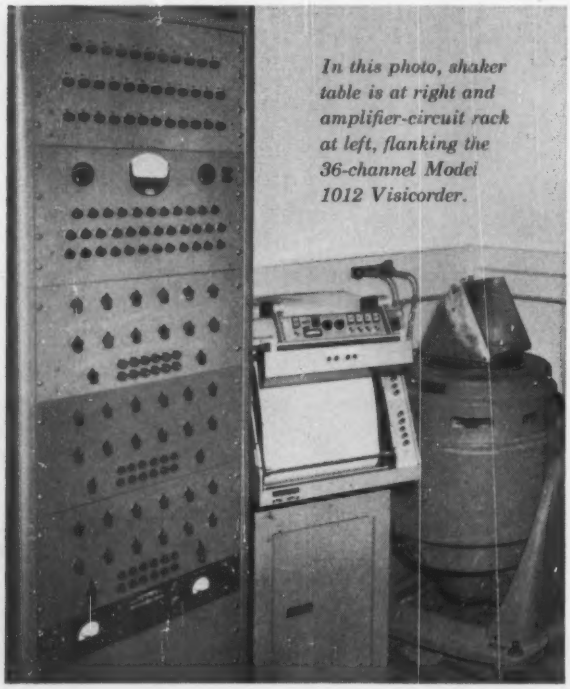
The VISICORDER records transistor torture

Transistors often have to work under incredibly severe environmental conditions. Production-testing them gave engineers at Honeywell's Semiconductor Division a chance to exploit the great versatility of the 36-channel Visicorder oscillograph Model 1012.

A certain order of transistors had to withstand vibrations of 10G at 10 to 2,000 cps without failing during the test or as a result of it. A standard test had been to measure the transistor's performance, next subject it to non-active vibration (not in any circuit), and then re-measure. This approach was obviously deficient as it did not reveal *operating* characteristics during test, nor did it disclose *intermittent*-type failures.



Unretouched record of vibration test on 36 transistors, each active in its own circuit during test.



In this photo, shaker table is at right and amplifier-circuit rack at left, flanking the 36-channel Model 1012 Visicorder.

The customer's quality requirements were stringent (AQL = .4%) and the large test sample required ruled out the use of an oscilloscope. The 3-hour test would have made a battery of scopes and operators necessary; transient defects would be missed due to eyestrain, fatigue, etc.

The Model 1012 Visicorder was chosen for the task as it simultaneously measures and records 36 channels of test information throughout the test period. The Visicorder instantly and directly records transients, no matter how random.

A Visicorder record like this is always a welcome supplement to your test data—your customer will be able to read it quickly and with full understanding. And it is a *permanent* record which *he* can show to *his* customer, if necessary.

For further information on how Visicorders can help to solve your instrumentation problems, contact your nearest Honeywell sales office without delay. Or write for Catalogs HC 906, 1012, 1108 and 1406, to:

Minneapolis-Honeywell, Heiland Division, 5200 East Evans, Denver 22, Colorado, SK 6-3681—Area Code:303

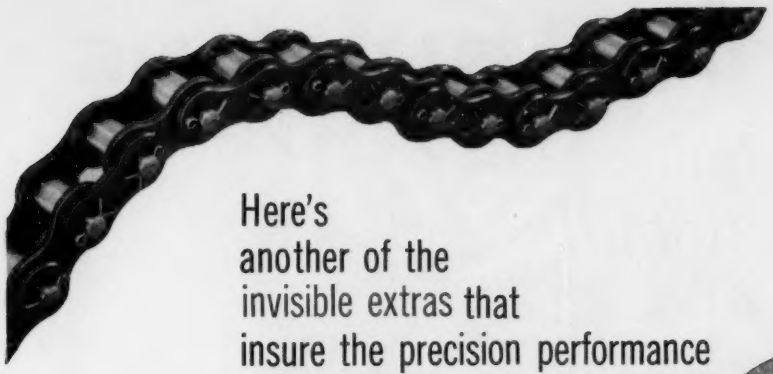
HONEYWELL INTERNATIONAL

Sales and Service offices in all principal cities of the world.

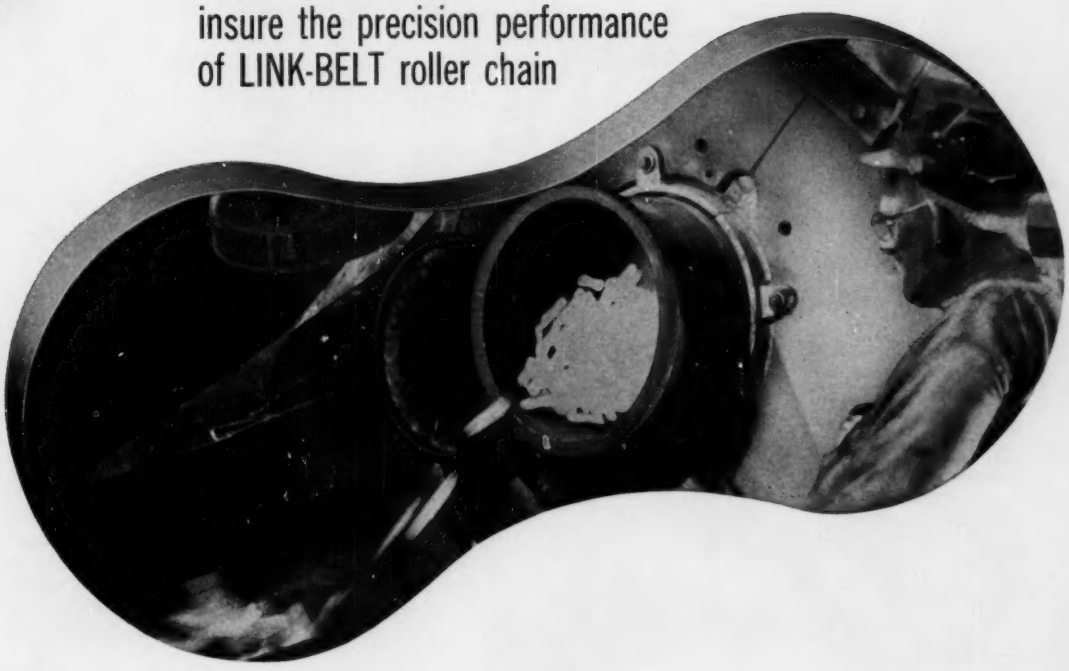
Honeywell

H Industrial Products Group

Circle 239 on Page 19



Here's another of the invisible extras that insure the precision performance of LINK-BELT roller chain

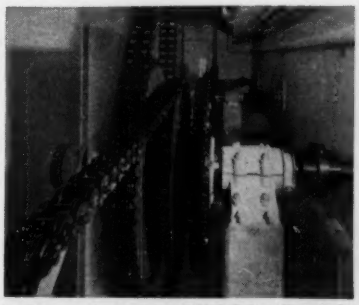


Painstaking precision of heat-treat control gives you

uniform strength in every link

To produce roller chain of utmost uniformity, Link-Belt maintains exacting control of all heat-treating processes. With equipment and instrumentation exactly tailored to the need, all processes are carefully adjusted to suit the characteristics of each heat and analysis of steel. Result: roller chain of uniform strength *well above accepted standards.* Chain that absorbs shock loads, delivers full power under continuous heavy going.

Precise heat-treat control is one of many *invisible extras* that contribute to the greater strength and endurance of Link-Belt roller chain. Others include prestressing, pitch-hole preparation, shot-peening. These features—plus painstaking precision and inspection in every step of manufacture—assure you of chain that can easily cope with today's heavy loads and high speeds.



Single and double strand Link-Belt roller chains combine to provide dependable, positive power transmission at this installation.

For engineering assistance in applying industry's preferred roller chain, contact your nearest Link-Belt office. See CHAINS in the yellow pages of your phone directory. Ask for Book 2657.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 19.595

LINK-BELT

ROLLER CHAINS AND SPROCKETS

Circle 240 on Page 19

DOT PLUG BUTTONS

fill holes functionally and decoratively

Inexpensive DOT Plug Buttons are ideal for covering drilled or molded holes in metal or plastic structures of all types. Finger pressure snaps them into place, spring tension holds them there without rattling even under conditions of severe vibration.

Used as covers for inspection or maintenance-access holes, Plug Buttons are easily removed and can be re-inserted repeatedly without lessening their effectiveness. Used in combination with plastic lens inserts, Plug Buttons make excellent indicator-light covers. Faceted, Fresnel-type or plain lenses can be made in a variety of colors and can be designed to show words, letters or symbols, according to the requirements of the particular application.

DESIGN ENGINEERING SERVICE

Designers, metallurgists and plastics specialists on DOT's engineering staff are equipped to work out optimum combinations of metal and plastics to suit your particular requirements. Hundreds of variations in shape, finish and material are possible.

The basic steel or brass Plug Button, for example, can be parkerized or polished or finished in chrome, nickel, zinc, copper or any of a wide variety of colored enamels. Designs can be stamped into the metal or molded Lucite lenses can be inserted.

Nylon, polystyrene or flexible polyethylene Plug Buttons can be molded to show trademarks, indicator symbols or any other design.

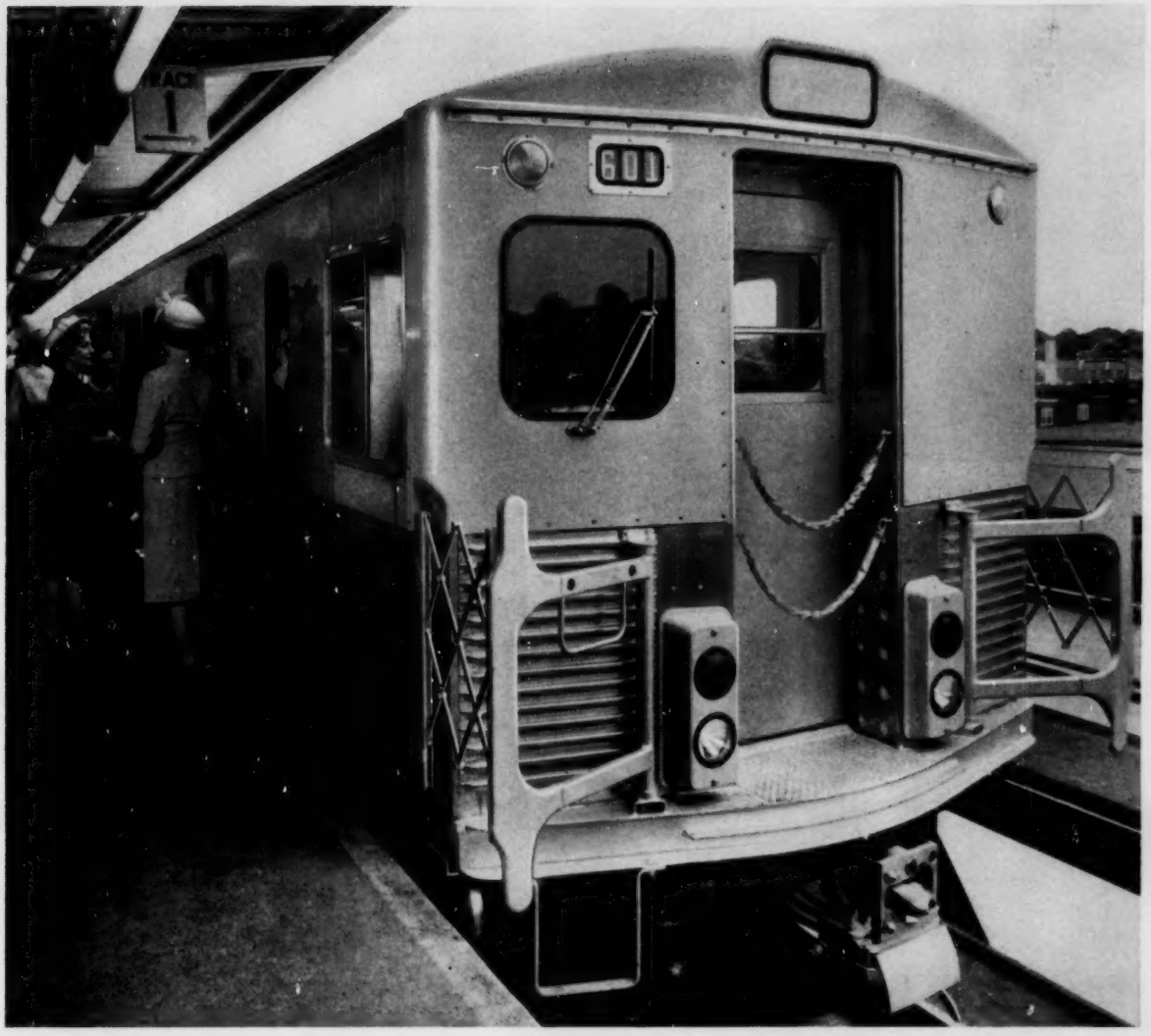
For further details, write for Engineering Data Catalog, Section D

MAKERS OF ★ DOT ★ FASTENERS

CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, San Francisco, Seattle, Syracuse



How Nickel Stainless Steel "lightweights" curb Philadelphia subway costs by $6.4 million

Commuters using the Market-Frankford elevated subway line in Philadelphia are smiling these days. So are transit authorities. That's because the line's new subway cars are the most modern in design for passenger comfort . . . and the most economical the city could buy.

Compared to competitive subway cars, during a 35-year depreciation period these new Nickel Stainless Steel cars will:

Operate on $2.4 million less power. They are solidly constructed, yet are so light they run on 12% less electric power than conventional cars based on the same specifications but fabricated from other materials.

Require $4 million less maintenance. Designed and built from Nickel Stainless Steel by The Budd Company to specifications set by the City of Philadelphia and the Philadelphia Transportation Company, these cars need no painting and virtually no exterior maintenance . . . because Nickel Stainless Steel resists corrosion and retains its handsome finish.

And because they are the lightest cars for their size ever built, they:

Help cut running time by 6 minutes. Thanks to the excellent combination of stiffness and high strength found in Nickel Stainless Steel, their thinner-gauge body shells reduce costly deadweight and make it easier for powerful motors to increase acceleration and braking rates.

Can Nickel alloys save you money? Alone or with other elements, Nickel improves hundreds of alloys, making possible almost any desired combination of properties for meeting specific service demands...while reducing long-term costs. For a guide to information about Nickel, its alloys, and their industrial applications, send for our catalogue of publications. Ask for List "A".

The International Nickel Company, Inc.
67 Wall Street INCO **New York 5, N. Y.**

Inco Nickel

Nickel makes alloys perform better longer

A full line of capacities from 10 to 52 points. Capable of millions of steps without adjustment.

Fast "Off-The-Shelf" delivery

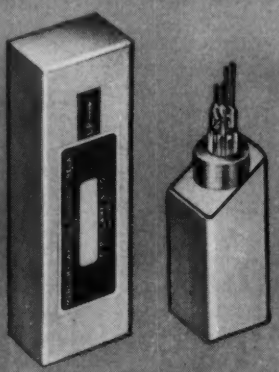
Overnight delivery on many items at factory prices

When standard CLARE relays or switches meet your needs, distributor service saves you time, costs you no more.

Top quality
—the same fine design and long life you get in CLARE custom-built relays and switches.

Easy purchasing
—you can order CLARE relays at the same time you purchase other components...have them delivered together.

Engineering assistance
—always available from CLARE field engineers who work in close cooperation with CLARE distributors.



NOW AVAILABLE
...mercury-wetted contact relay modules for mounting on your own printed circuit board

Type HGM relay module (left) with cut-away (right) showing mercury-wetted switch capsule and coil potted in steel enclosure.

Your nearby CLARE distributor can now supply you with the new CLARE mercury-wetted relays, steel enclosed and ready for mounting. They combine the famous CLARE billion-operation reliability with unusual ease of handling and application. You can choose either the standard CLARE HG relay module or the HGS, super-fast and super-sensitive. Each module contains the CLARE mercury-wetted contact switch capsule with contacts continually wetted by capillary action. They never bounce, never get dirty, never weld and never wear out.

A compact telephone type relay of unequaled long life and superior performance.

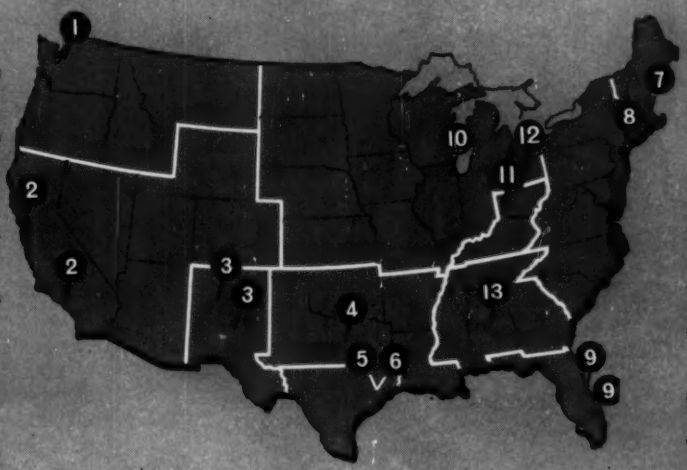
A highly reliable switching device for single or multiple circuit control...wide mounting versatility.

Single or multiple switch capsules potted in steel container. Gives billions of operations with no maintenance.

A crystal can relay with unusual flexibility and a variety of mounting styles.

# of top-quality Clare relays

From these distributors



PACIFIC COAST

1. **Puget Electro Products**
3028 First Avenue,
Seattle 1, Washington
2. **Bell Electronic Corporation**
306 E. Alondra,
Gardena, California
2. **Bell Electronic Corporation**
1070 O'Brien Drive,
Menlo Park, California

SOUTHWEST

3. **Radio Specialties Co., Inc.**
6323 Acoma Road, S.E.,
Albuquerque, New Mexico
3. **Radio Specialties Co., Inc.**
209 Penn Avenue,
Alamogordo, New Mexico
4. **Engineering Supply Company**
6000 Denton Drive,
Dallas 35, Texas
5. **Harrison Equipment Co., Inc.**
1422 San Jacinto St.,
Houston 1, Texas
6. **Busacker Electronic Equipment Co., Inc.**
1216 West Clay St.,
Houston 19, Texas

EAST

7. **R & D Supply, Inc.**
1492 Highland Ave.,
Needham 92, Massachusetts
8. **Avnet Electronics Corporation**
70 State Street,
Westbury, L. I., New York
9. **Electronic Wholesalers, Inc.**
1301 Hibiscus Boulevard
P. O. Drawer 1655,
Melbourne, Florida
9. **Electronic Wholesalers, Inc.**
61 N.E. Ninth Street,
Miami 32, Florida

CENTRAL

10. **Reiny Sales, Inc.**
P. O. Box 186,
West Chicago, Illinois
11. **Srepco, Inc.**
314 Leo Street, Dayton 4, Ohio
12. **Pioneer Electronic Supply Company**
2115 Prospect Avenue,
Cleveland 15, Ohio
13. **M G Electronics & Equipment Co.**
201-3 South 18th Street,
Birmingham 3, Alabama

For more complete information on the full line of CLARE components, address:
C. P. Clare & Co., 3101 Pratt Blvd.,
Chicago 45, Illinois.
In Canada: C. P. Clare Canada Limited
840 Caledonia Road, Toronto 19, Ontario.
Cable Address: CLARELAY

C. P. CLARE & CO.

Relays and related control components

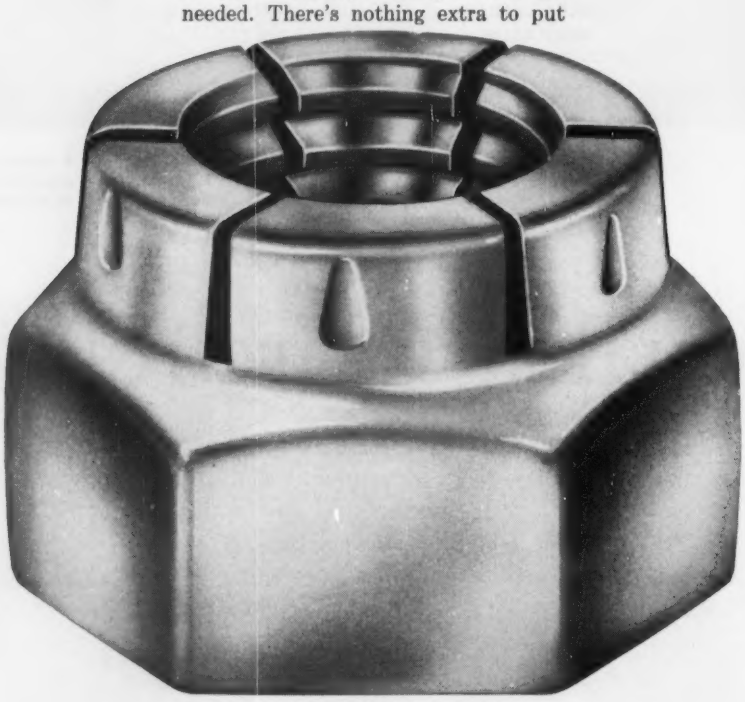
Circle 273 on Page 19

Stays put . . . for keeps

FLEXLOC

Put FLEXLOCs on your assemblies and relax. They're going to stay put . . . "for keeps" . . . regardless of the shock, the pounding, the vibration. These self-locking nuts simply won't work loose.

With the 1-piece all-metal FLEXLOC, no lockwashers, jam nuts, cotter pins, or other auxiliary locking devices are needed. There's nothing extra to put



together, come apart or get lost. Assembly time and costs are reduced; also maintenance expenses, because FLEXLOCs can be removed and reused.

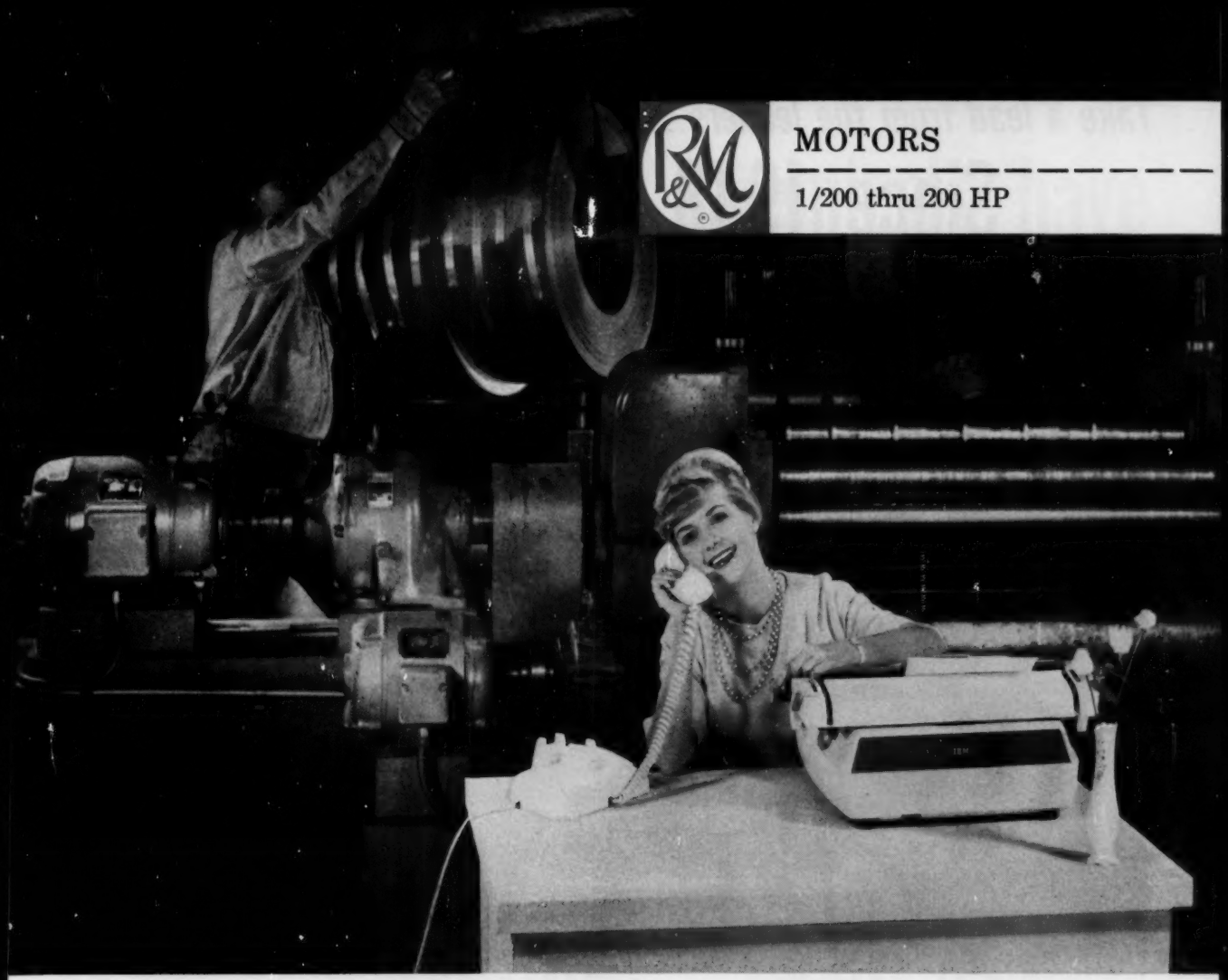
One more major FLEXLOC feature: they lock seated or not once 1½ threads of the bolt are past the top.

So insist on FLEXLOCs and keep your assemblies operating at full efficiency . . . full time. Available in light or heavy duty hex. See your authorized industrial distributor for complete information on sizes, materials and finishes. Or write STANDARD PRESSED STEEL — manufacturer of precision threaded fasteners and allied products in many metals.

INDUSTRIAL FASTENER Division

JENKINTOWN 18, PENNSYLVANIA **sps**

where reliability replaces probability



MOTORS

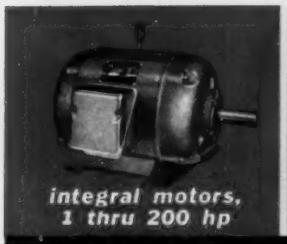
1/200 thru 200 HP

from machine tools to typewriters . . .

. . . Robbins & Myers motors power them all!

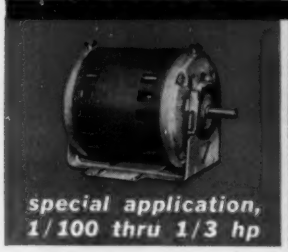
Each R&M motor, 1/200 through 200 HP, is electrically and mechanically designed with life-prolonging features which assure dependable operation, simplified installation and low maintenance. From rugged machine tools to complex business machines, there's an R&M motor for every job . . . Fractional and Integral H.P. Motors and Motor Parts in all popular mountings, electrical types and enclosures. Most are ready for off-the-shelf delivery. Others can be quickly produced. Should you require custom motors, R&M's experienced application engineers, aided by modern electronic computers, can furnish the one design best suited to your needs.

Write today for information, or send your powering problem to R&M. No obligation, of course!



integral motors, 1 thru 200 hp

fractional motors, 1/200 to 1 hp



special application, 1/100 thru 1/3 hp

universal or series parts, 1/50 to 1/2 hp

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators

Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

Circle 275 on Page 19

Take a lead from the leaders...

Since 1948, Amchem ALODINE* treated over 1½ Billion square feet

Popular Reynolds Colorweld pre-tinished aluminum panels find wide application in commercial construction where its enduring performance and good looks are helping to change the architectural face of industry. Alodine contributes its protective qualities to Colorweld's amazing paint performance.

Conversion Coating Chemicals have of Aluminum in Reynolds Plants!

From 1955, when Reynolds Colorweld** Production was started, Reynolds has used ALODINE; Continue to Report Complete Customer Satisfaction with Paint Adhesion on this Quality Pre-Enameled Aluminum Product

At two Reynolds producing facilities—Atlanta, Ga. and McCook, Ill.—Alodine chemicals used in the pre-paint treatment of Colorweld offer a typical example of Reynolds' continuing emphasis on product quality.

Each day at these plants thousands of feet of aluminum are treated with Alodine to provide the metal with a chemical coating which produces high quality paint bonding characteristics so essential to the durable Colorweld finish Reynolds demands.

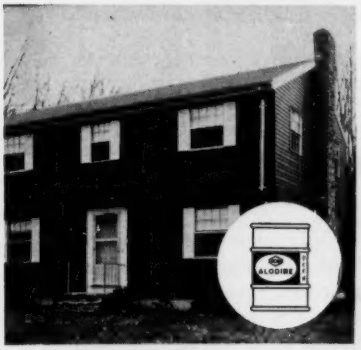
Alodine provided the first economical treatment that made possible the mechanical forming of pre-painted aluminum. Under extremely high volume processing speeds, the outstanding attributes of Alodine benefit aluminum products of all types—through improved paint bonding for subsequent mechanical forming operations, that means extra years of wear for painted aluminum under all types of environmental conditions.

Behind the success of Alodine as the outstanding pre-paint treatment for aluminum stand the research and development activities of Amchem's Metal Protection Laboratories where the search continues for even more efficient aluminum treating chemicals.

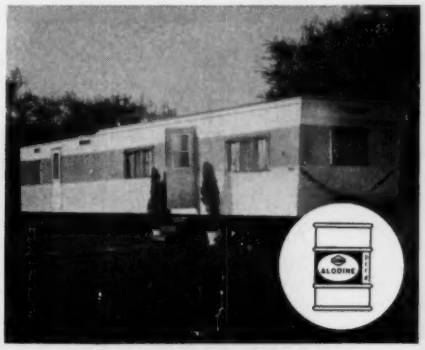
Take a lead from the leaders. If you're producing aluminum—bare or coated—specify Alodine for the assured quality and added beauty of your finished product.

*Amchem's registered trademark for its conversion coating chemical for aluminum.

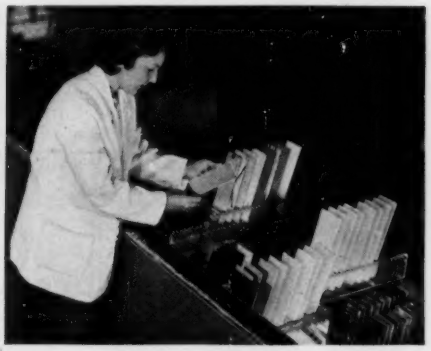
**Colorweld is a registered trademark of the Reynolds Metals Company.



Beauty and durability characterize siding of Reynolds Aluminum Colorweld for home use. Alodine chemicals help provide a paint bond that lasts and lasts.



This home-on-wheels has more appeal, will last longer thanks to its body of Reynolds Aluminum Colorweld, and a firm paint bond thanks to Alodine.



At Amchem's Metal Protection Laboratories exhaustive quality control testing assures the performance of Alodine chemicals for every aluminum pre-paint requirement.

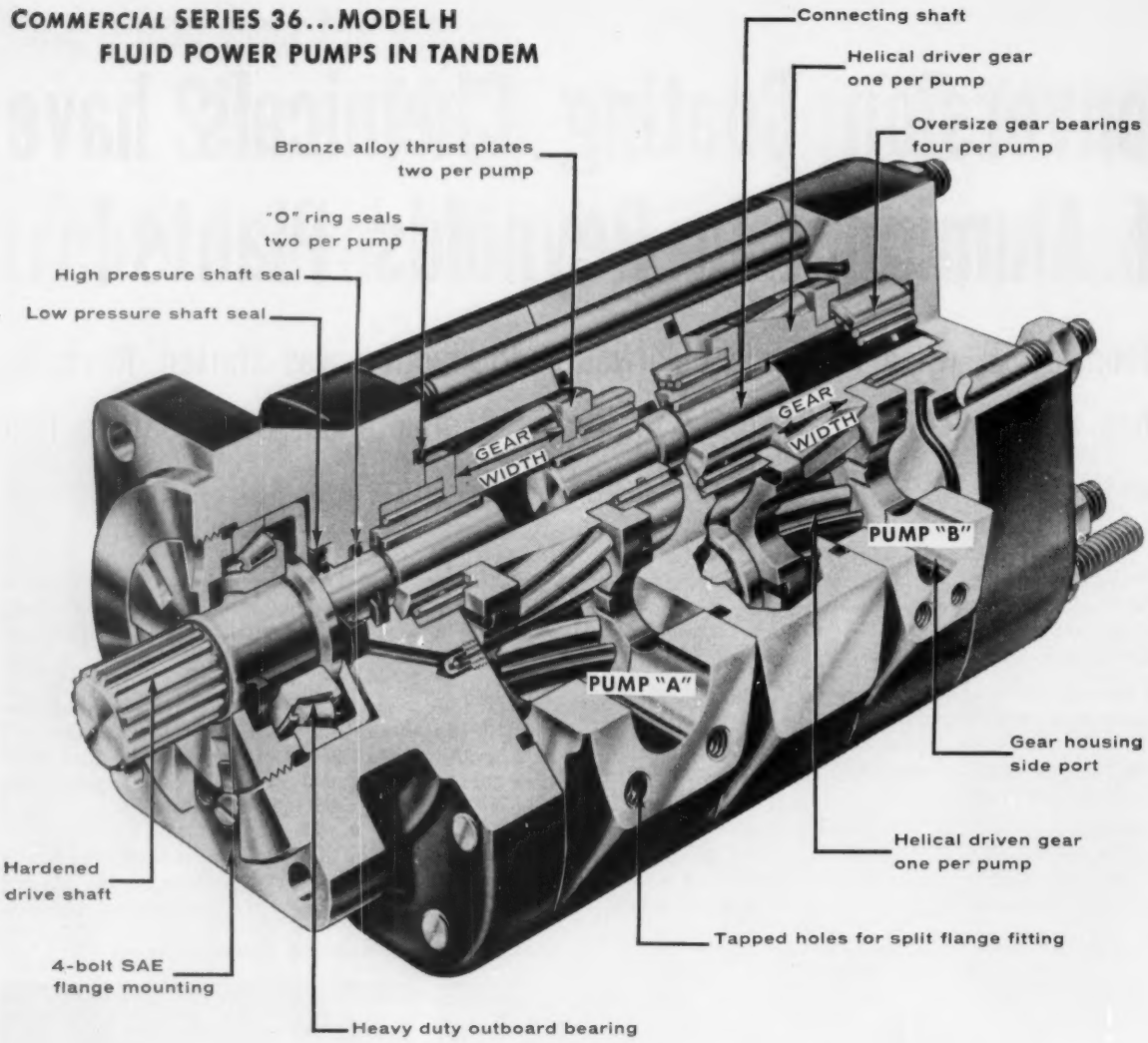
AMCHEM **ALODINE**

Amchem is a registered trademark of
AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)
AMBLER, PA. • St. Joseph, Mo. • Detroit, Mich. • Niles, Calif. • Windsor, Ont.

Write for Bulletin 1424C, gives detailed technical specifications on different Alodine chemicals available for pre-treating aluminum.

Circle 276 on Page 19

COMMERCIAL SERIES 36...MODEL H
FLUID POWER PUMPS IN TANDEM



How to "direct drive" multiple pumps

with –

one prime mover...
one mounting...
one drive shaft...

—another COMMERCIAL exclusive!

As many as 6 single COMMERCIAL 36H pumps can be assembled in tandem, back to back. With all pumps delivering at 2000 psi continuous duty, total gear width summation can be as much as 6 inches. Should discharge demand of any of the pumps be less than 2000 psi, total gear width can even exceed 6 inches.

GEAR WIDTH SUMMATION FORMULA
(based on pumps A, B, ··· F)
A pump (GxP) + B pump (GxP) + ··· F pump (GxP) = 12,000
(G = gear width (in.) of single pump; P = operating pressure (psi) of single pump; 12,000 = constant)

COMMERCIAL 36H single pumps are made in ½", 1", 1½", 2", 2½" and 3" gear widths covering a range of delivery from 7 to 42 gpm (rotation 1500 rpm—operating pressure 2000 psi).

NFPA NATIONAL FLUID POWER ASSOCIATION ENERGY FOR INDUSTRY

Personal technical service and assistance is yours for the asking. For more information write to Commercial Shearing & Stamping Company, Youngstown 1, Ohio. U.S.A. Attention: Dept. S-17.

COMMERCIAL shearing & stamping

Down . . . down . . . down to ± 10%. Ohmite now offers this low "K" tolerance as *standard* for all three *commercial*, "hat-shape" slug capacitors.

Resulting from advanced manufacturing processes and quality control techniques, this new engineering development improves previous broad tolerances of −15+20% and −15+50%.

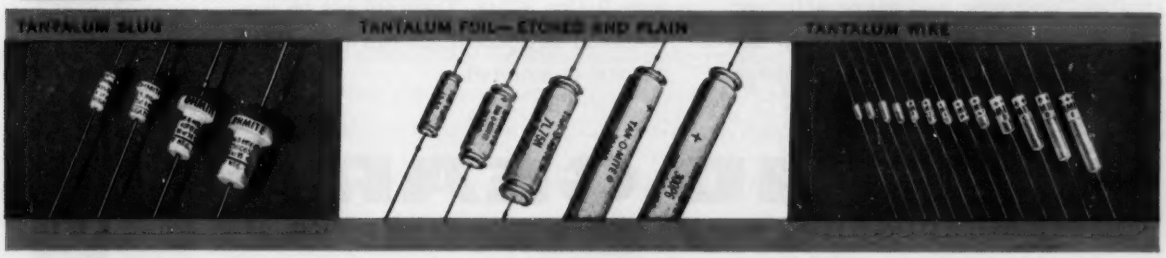
Ohmite also supplies the three "hat-shape" sizes—T1, T2, T3—in S and T tolerances according to the latest requirements of MIL-C-3965B, styles CL44 and CL45.

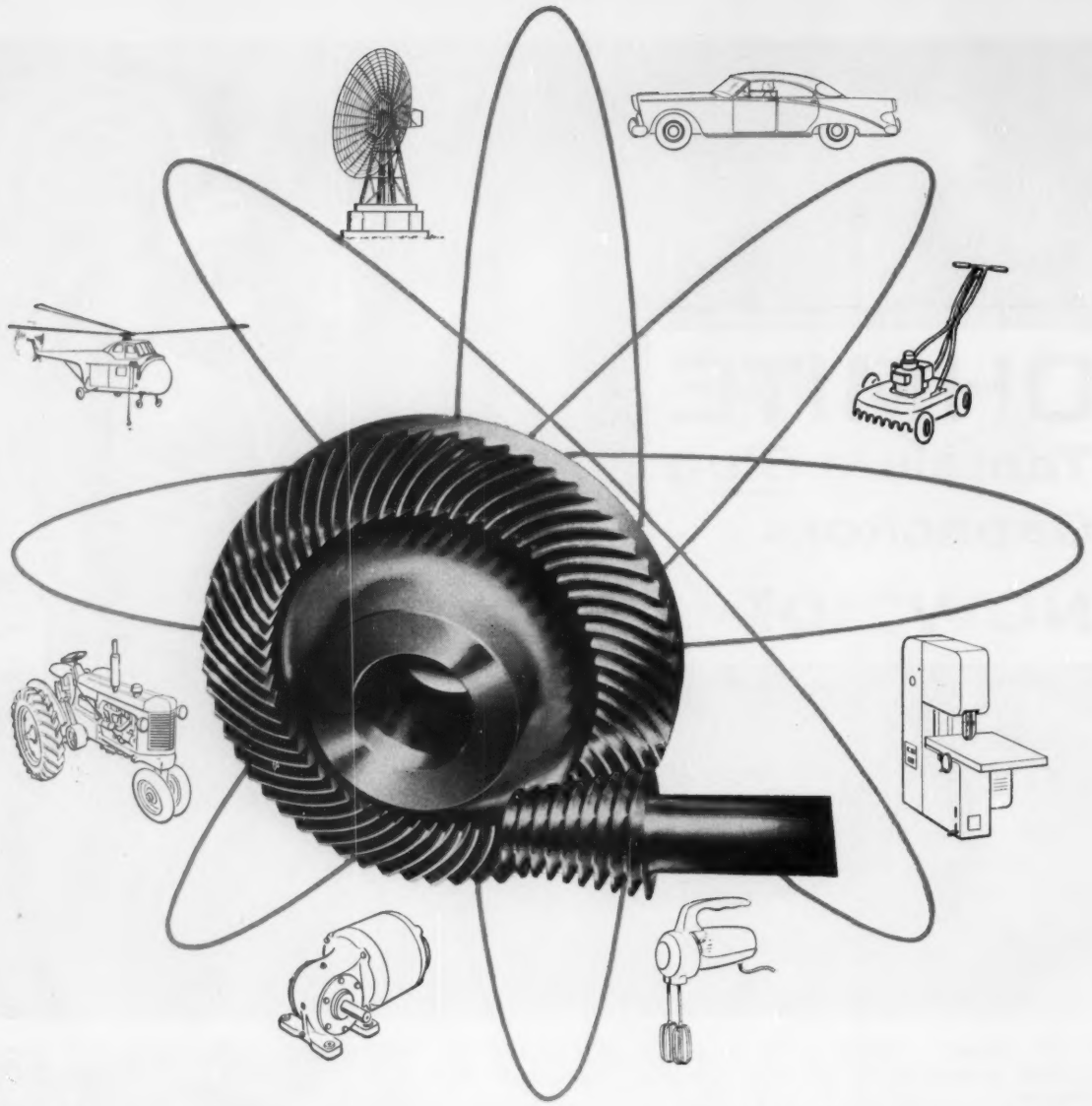
For the complete picture of Ohmite's *big, full line* of wet-electrolytic tantalum slug capacitors, *request Bulletin 159F today!*

OHMITE

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois
Rheostats Power Resistors Precision Resistors
Variable Transformers Tantalum Capacitors
Tap Switches Relays R.F. Chokes
Germanium Diodes Micromodules

Fast Delivery of MIL and Commercial Stock Values From Factory and Distributors





NEW DESIGN HORIZONS
for your product

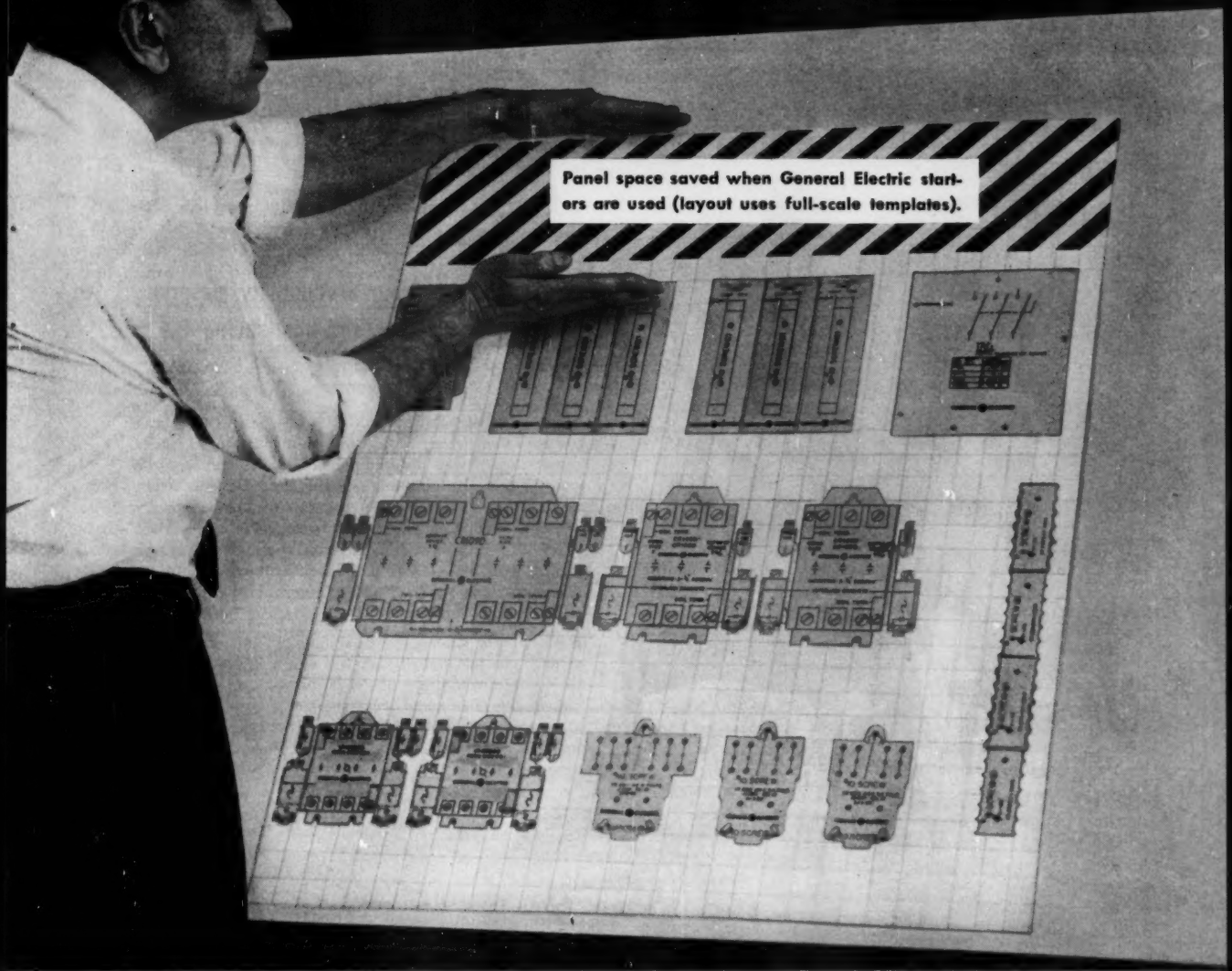
SPIROID® GEARS SAVE SPACE—SAVE WEIGHT . . . OFFER POSITIVE BACKLASH CONTROL

Spiroid Gears extend the horizon of mechanical frontiers, offer new product design opportunities for increased performance standards. Comparatively smaller, stronger and more efficient, Spiroid Gears provide an entirely new relationship between power transmission and gear size. You get more power from less space, more profit from your product. Spiroid Gears can be produced in standard gear materials in any size and in ratios from 9:1 to 300:1. They are cut on conventional equipment, or can be molded, die-cast or sintered.

Send for your free file, "Low Cost design begins with Spiroid's family of modern gears." Booklets on Planoid® and Helicon® gears will be included.

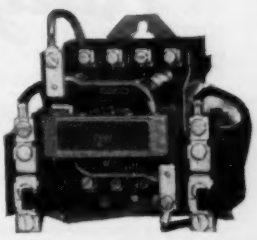
SPIROID GEARS
SPIROID DIVISION OF ILLINOIS TOOL WORKS

2501 N. Keeler Avenue, Chicago 39, Illinois



The Size of This Panel Shrunk 12%, Construction Costs Dropped When General Electric Starters Were Used

The panel above was first laid out with another make magnetic starter. Then, General Electric starters were substituted, and size was reduced 12 percent. Space savings like this mean important savings in steel and construction costs. You might even make the panel an integral part of your machine rather than mount it separately. Or perhaps you'll be able to use a *standard* enclosure rather than a larger, more costly special. Since G-E starters are smaller and have full-front accessibility, you can locate wiring channels closer together, considerably reducing vertical panel space. Your G-E sales engineer can show you many more MEASURABLE ADVANTAGES. Call him today, or write for Publication GEA-7020. General Electric Co., Section 811-17, Schenectady 5, N.Y.



Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 280 on Page 19

Is your materials-handling equipment years ahead of your engineering design equipment?

Save all the money you can with the latest materials-handling devices—but don't overlook your drafting department, either! Professional draftsmen really deserve the latest equipment—it's just *good business* for you to see that they have it.

Your draftsmen, your productivity, deserve new Hamilton space- and time-saving equipment from Ridgway's

Top engineers or draftsmen do their very best work at peak efficiency—when they work with high-quality, *professionally designed* equipment. It's a morale-boosting compliment to a good man to give him the *best* equipment. He feels better, works harder, makes fewer errors. And the genuine quality in each Hamilton unit will actually save real money over the years. Why not gain the plus benefits of modern styling at a modest investment—plus the better working atmosphere Hamilton units provide? Our planning engineers are as close as your phone!

HAMILTON CL-100 TABLE Entirely new, canted-leg styling assures stability without side crossrails. Strata-Core board, with green linoleum surface, both sides steel edged; tilts 0° to 40°. Fully adjustable recessed footrest; steel reference, tool, and catalog drawers. Other fine features, superb styling in light Sahara Tan, satin-chrome hardware.

Hamilton L-Contour Table
Prestige-assured, individualized work area providing complete board adjustment plus extra storage and reference area.

Hamilton Unit System Files
Provide full protection, accessibility, and classification for all materials to be filed. Occupy minimum floor space.

Hamilton Auto-Shift Table
Built-in mechanism adjusts board to individual height and slope requirements, provides full accessibility, reduces errors.

Ridgway's LLR

There's a Ridgway's near you.

in **HOUSTON,** Texas
615 Caroline
3800 Greenbriar
Bank of the Southwest Arcade

in **AUSTIN,** Texas
309 W. 10th Street

in **CORPUS CHRISTI,** Texas
516 Lawrence

in **DALLAS,** Texas
933 N. Central Expressway
933 Republic National Bank

in **NEW ORLEANS,** La.
433 Dryades Street

in **SHREVEPORT,** La.
719 Marshall Street
Petroleum Tower Building

in **TULSA,** Okla.
701 S. Cincinnati
5925 East 15th

in **JACKSON,** Miss.
103 East Pearl

in **IRVINGTON,** N. J.
1206-16 Grove Street

in **CHICAGO,** Ill.
10130 Franklin Avenue
Franklin Park

in **DENVER,** Colo.
1522 Glenarm Place

in **LOS ANGELES,** Calif.
590 So. Monterey Pass Road
Monterey Park

in **NEW YORK,** N. Y.
110 W. 42nd Street
216 E. 49th Street

in **FORT WORTH,** Texas
309 Main Street
3312 Fairfield

Ridgway's Dealers Coast-To-Coast

Circle 251 on Page 19

first in silicones

Dow Corning

SILICONE NEWS

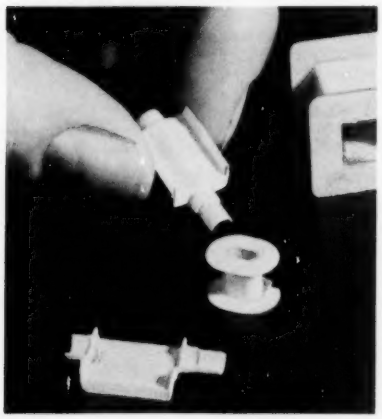
for design and development engineers • No. 82

Silicones Simplify Miniaturization

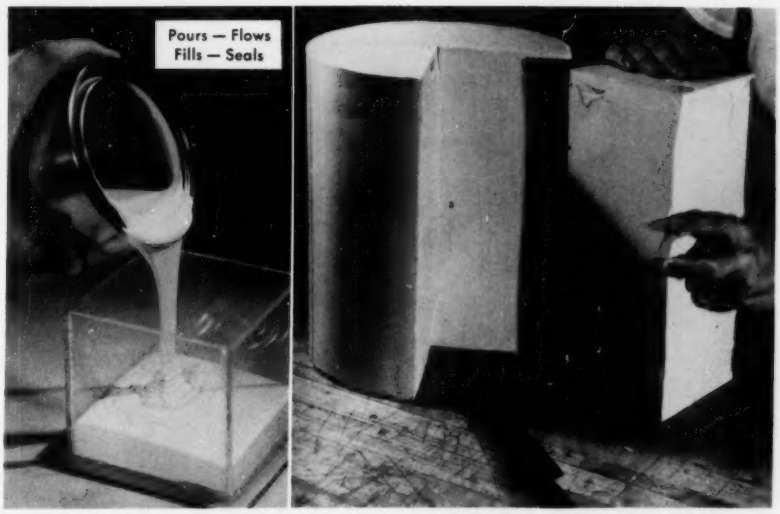
Miniaturization means heat. Heat that has to be dissipated from smaller surface areas. Temperatures go up — and materials like Dow Corning Silicones come into their own!

Take silicone-glass laminates, for example. At high temperatures they have dielectric properties that are superior to those of other laminated materials. In addition, silicone-glass laminates have excellent resistance to ozone, arcing, corona, and fungus attack . . . even the formidable combination of high humidity and high voltage.

Mechanical strength is good — permitting thin, rigid coil bobbin walls, more winding space and better resistance to winding pressure. One-piece laminated coil bobbins, like those shown, are used in continuous operation at 250 C, have been tested at 400 C for 1,000 hours.



These are reasons why the Foster Transformer Company, Cincinnati, Ohio, specifies coil bobbins of silicone-glass laminates made by Silicone Insulation Inc., Bronx, N. Y. These small, sturdy coil bobbins are part of computer *(Cont. Pg. 2)*



Cold Cures In Thick Sections

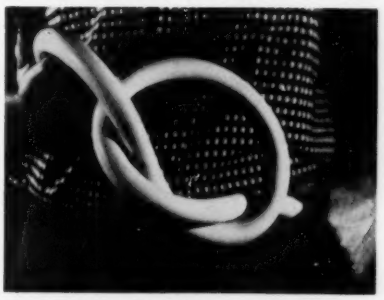
New and available — a free-flowing fluid silicone rubber that vulcanizes in sections of unlimited thickness and at room temperature!

Identified as Silastic® RTV 601, the new rubber cures without heat, pressure or moisture . . . even under totally confined air-tight conditions. All that's required is the addition of a catalyst and 24 hours time to set up into a rubbery solid. Variations in thickness have no significant effect on curing rate and uniformity. Venting during cure is unnecessary because no volatile by-products are produced by the vulcanization reaction.

The handling characteristics and properties of Silastic RTV 601 suggest usefulness in a variety of applications ranging from the making of flexible molds and casting of prototype parts to potting and encapsulating deep or totally enclosed electrical and electronic components. Supplied as a low viscosity fluid rubber, it flows into and around the most intricate designs, completely filling narrow cavities and hairline cracks.

After vulcanizing 24 hours at 77 F, parts or sections made from Silastic RTV 601 can immediately be put into full service at temperatures from —100 to 500 F. Physical and electrical properties are consistent through all dimensions of a section.

Another important feature of this RTV (room-temperature-vulcanizing) silicone rubber is control over set-up time. Under normal conditions, Silastic RTV 601 will



set up to a tack-free solid within 12 hours after catalyzation. By adjusting the catalyst concentration or the cure temperature, set-up time can be lengthened or reduced as desired — without affecting final properties.

For a sample of new Silastic RTV 601, write to Dow Corning Corporation, Midland, Michigan on your business letterhead. For additional information, circle **No. 241**

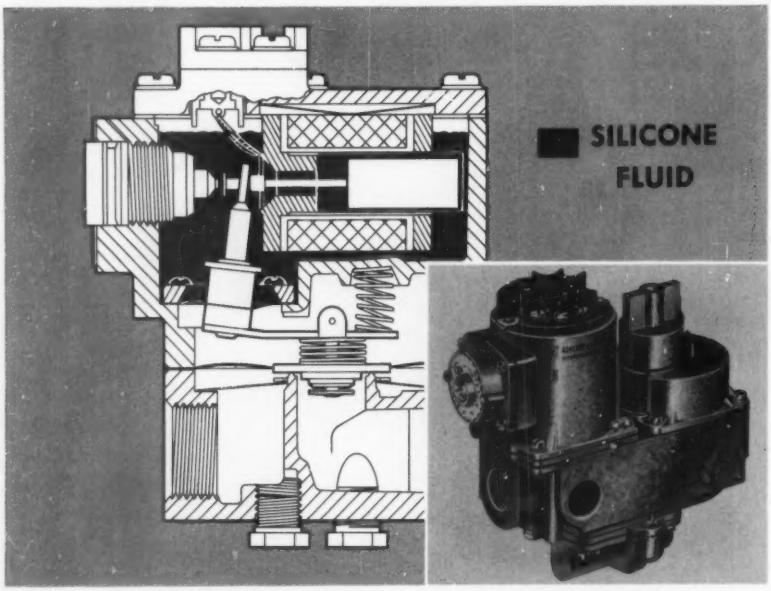
See Silicones At Booth 644

1961 DESIGN ENGINEERING SHOW

MAY 22 through 25 COBO HALL, DETROIT

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE OR REFERENCE NUMBER ON READER SERVICE CARD

MORE



SMOOTHS CONTROLS

Engineers at General Controls Company, Glendale, California, designed their Dial-A-Flow gas valve so that the operating mechanism is immersed in Dow Corning 200 Fluid.

Result: This viscous silicone fluid cushions the snap action of the mechanism and makes it silent. The undesirable pop of gas ignition and noise of plunger impact are eliminated. Wide rangeability of the Dial-A-Flow valve permits heating equipment manufacturers to use just one valve for most of their input requirements.

Job-proved as the ideal fluid damping medium, Dow Corning 200 Fluid doesn't thicken or thin with temperature change . . . assures uniform performance over wide temperature spans. Resistant to oxidation and to breakdown under shear, and characterized by excellent dielectric properties, Dow Corning 200 Fluid increases reliability of performance of a wide variety of industrial and military components and accessories — sensitive motion detectors, accelerometers, instruments and gages; automotive fan drives and torsional vibration dampers; liquid springs; and hydraulic couplings.

For more information about Dow Corning silicone fluids — and how their unusual combination of properties makes design changes possible, circle . . . ***No. 242***

SILICONE GLASS *(Cont.)*

power transformers that weigh only 0.85 pounds each . . . that must give dependable service in airborne guidance control systems.

Coil bobbins made of silicone-glass laminates are used by Foster in filter chokes and output transformers as well as in computer power transformers . . . and each of these units is impregnated with Dow Corning silicone varnish to assure reliability of miniaturized designs.

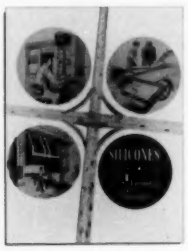
For more information about properties and applications of glass laminates made with Dow Corning Silicones, circle ***No. 243***

new literature and technical data on silicones

How to insulate motor coils with self-adhering silicone rubber tape is described step by step in a four-page, illustrated data sheet. Benefits listed include protection of components against hazards of high humidity, vibration, thermal expansion and mechanical shock. ***No. 244***

Up-to-the-minute. The new Engineering Guide to the Properties and Applications for Dow Corning Silicone Products is now available. This 16-page brochure contains the most current information on all lines, all forms of silicone products manufactured by Dow Corning for engineering applications. Bring your reference files up-to-date by encircling . . . . . ***No. 245***

Silicones for the Automotive Industry is the subject of an eight-page brochure that cites illustrations and descriptions of the many research, engineering, and automotive production applications wherein silicones make possible superior performance. Some of the applications include power plants, braking systems, power transmissions, electrical components, surface protection, lubrication, and many more applications of interest to every design engineer. ***No. 246***



Job-proved Dow Corning silicone lubricants help designers solve lubrication problems created by adverse operating conditions. Used on equipment ranging from freezers to core oven conveyors — at temperatures as low as minus 100 F, as high as 500 F. Send for a handy brochure on properties and applications. ***No. 247***

Wherever there's a problem — gaskets, seals, O-rings . . . rubber parts fabricated of Silastic, the Dow Corning silicone rubber, stay rubbery in spite of heat, cold, compression, weathering or ozone, moisture or steam, oils, fuels, or chemicals that often cause problems. This six-page, illustrated brochure cites how these problems are overcome by the use of Silastic . . . to increase the life and reliability of scores of units while reducing maintenance costs and frequently simplifying design. ***No. 248***

Dow Corning Corporation, Dept. 4916, Midland, Michigan

Please send me: 241 242 243 244 245 246 247 248

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for design and development engineers by

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

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Another ***TUTHILL*** *Application*

TUTHILL PUMPS Lubricate GARDNER-DENVER'S RP-900 Compressor

Gardner-Denver describes its new model RP-900 as "the finest rotary compressors on the market". Developed for operation under the most extreme climatic conditions the new units are designed to provide the greatest possible dependability in the roughest service.

Essential to the RP-900's dependable performance is its lubricating oil pump. Gardner-Denver selected Tuthill to work with its engineers in developing a unit which would provide positive and metered oil-flow to assure lubrication, cooling and sealing under all operating conditions.

Tuthill's standard pump 5C, especially modified to meet the demands of this particular application, was selected. Adapted for operation at 1800 rpm, the Tuthill unit is mounted directly on the compressor rotor shaft. Special mounting brackets and shafts, developed by Tuthill's engineers, facilitate assembly and maintenance of the compressor.

800 Standard Models

The model 5C, modified for use by Gardner-Denver, is only one of over 800 standard models in Tuthill's complete line . . . providing a complete selection for a wide variety of requirements in lubrication, hydraulic, coolant, refrigeration, air conditioning, and many other services.

Very probably a Tuthill model will supply an economical, dependable answer to your pumping problem. For special applications, Tuthill's engineers have extensive experience in modifying these standard units, as for Gardner-Denver above. Or they will work with you in developing an entirely new unit, adapted in every detail to the requirements of your application.

Catalog 100 gives an over-all picture of Tuthill's complete line. Write for your copy today. Or, to speed things up, send drawings or other information on your application so that our engineers can indicate ways in which Tuthill's pump know-how can save you money.

Tuthill manufactures a complete line of positive displacement rotary pumps with capacities from ⅓ to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm.

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Circle 252 on Page 19

Flexonics Hi-Flex is a new, *all-new* corrosion-resistant, helically-formed metal hose. It is new in design, new in method of tube forming, new in manufacture . . . and it is subjected to the most rigid quality control. Hi-Flex hose is your answer for cryogenic applications, where cleanability, high pressures, and wide temperature ranges are critical . . . for hydraulics and pneumatics, where pressures and flexibility are design criteria . . . and for many other demanding aeronautical, missile, and industrial applications.

Hi-Flex hose is available for low, medium, and high pressures, in sizes from ¼" through 1¼". Mail coupon for copy of new Catalog 200E.

IH-465

Flexonics

FLEXONICS CORPORATION • BARTLETT, ILLINOIS
In Canada: Flexonics Corporation of Canada, Ltd., Brampton, Ontario

METAL and SYNTHETIC HOSE
EXPANSION JOINTS
BELLOWS • SPECIAL TUBULAR ASSEMBLIES

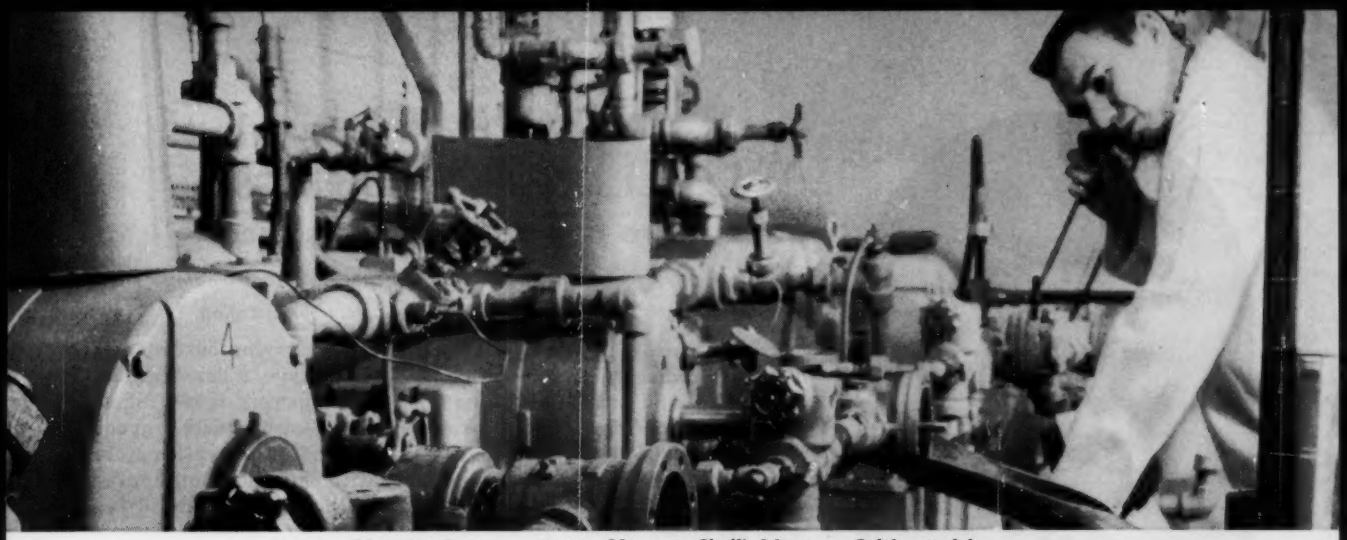
SUBSIDIARY OF CALUMET & HECLA, INC.

Mail this coupon TODAY!

ATTACH TO YOUR LETTERHEAD

Flexonics Corporation
350 E. Devon Avenue
Bartlett, Illinois

Gentlemen:
Please send me a copy of your new Catalog 200E, on Flexonics Hi-Flex Metal Hose.



Listening for pump chatter. Here—in Shell's Martinez, California, laboratory Shell Tellus hydraulic oils are subjected to the most demanding tests.

BULLETIN:

Shell presents a question-answer guide to help you select the hydraulic oils for top performance

Selecting the proper hydraulic fluid for your equipment can be one of your most important decisions. And it can pay off in many ways. Less down-time. Longer equipment life. Lower cost per unit.

Here are six bench marks to help you pick the best hydraulic oil for your plant requirements.

1. Does it have good oxidation stability? Oxidized hydraulic oil can form gums, lacquers and other deposits which may foul moving parts. Shell Tellus Oils are carefully refined to remove unstable, sludge-forming components—then fortified with a Shell-developed oxidation inhibitor.

2. Will it resist foaming and emulsification? Pump chatter and erratic operation are often the result of pump cavitation, brought on by oil foaming. Tellus® Oils contain additives to help prevent foaming.

3. Does it fight rust and corrosion? It is difficult to exclude all moisture from a hydraulic system. And moisture can form troublesome rust. Shell Tellus Oils have been carefully compounded to resist corrosion.

4. What are its lubrication qualities in continuous service? Shell Tellus Oils form a clinging, oily film on mating metal surfaces. This maintains a constant guard against wear.

5. How does it react to temperature changes? This is a key factor in the performance of hydraulic equipment. Careful selection of the proper viscosity grade of Tellus assures satisfactory operation of your system over its entire temperature range.

6. Is it available in several viscosity grades? Shell Tellus Oils are available in a broad range of viscosity grades. There's a special grade for virtually every hydraulic requirement.

Ask your Shell Industrial Products Representative for facts on Tellus Oils. Or write: Shell Oil Company, 50 West 50th St., New York 20, N. Y.

A message to manufacturers of hydraulic equipment

There is a Shell Tellus Oil suited for your equipment.

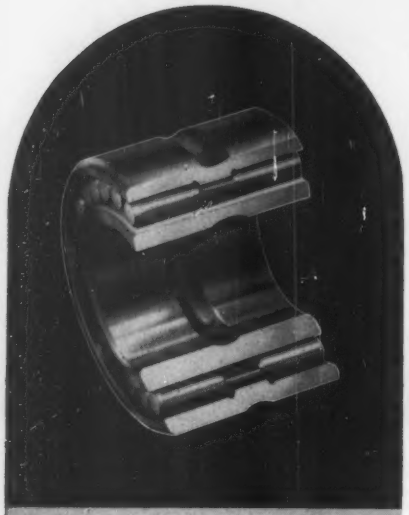
1. Your customers can get Tellus Oils at Shell depots everywhere. Readily available throughout the world.

2. Quality is consistently high. Tellus always delivers top performance.

SHELL

A BULLETIN FROM SHELL
—where 1,997 scientists are working to provide better products for industry

Circle 256 on Page 19

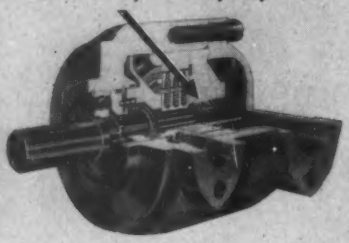


McGILL® GUIDEROL® BEARINGS
pack more capacity in less space

- *Center-guided rollers limit skewing tendency, prevent binding*
- *Integral seals increase life — avoid frequent relubrication*

GUIDEROL bearings provide the maximum load carrying surface and minimum radial dimension advantages of full-type roller bearings — plus free and accurate tracking where misalignment is controlled. They are especially suited to vertical mounting. Sealed models keep out abrasive and lube-diluting contaminants — and avoid relubrication problems. These heavy duty units are available with or without inner races with bore sizes from ½" to 9¼". Typical applications and their advantages are shown below.

GUIDEROL® compactness and high load capacity utilized in DENISON hydraulic pumps



The Denison Engineering Division of American Brake Shoe Company cites compactness, high load capacity and separable design as advantages of the McGILL GUIDEROL bearings which they use to carry externally applied loads in their "T" Series Balanced Vane Hydraulic pumps. Denison Engineering also state that they have benefited from "Good delivery and cooperation from McGILL Engineering on new development."

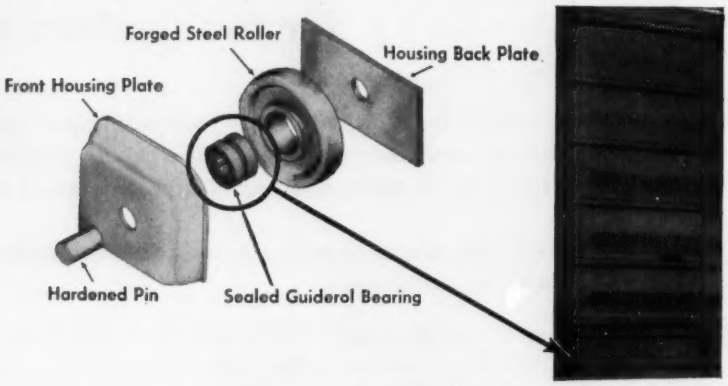
Typical applications of Denison "T" Series Balanced Vane Pumps are for continuous 2000 psi service in earthmoving equipment, and similar types of mobile equipment; special machinery, such as extrusion presses and in automation feed service and index mechanisms.

Integral seals protect operation of GUIDEROL® bearings in PULLMAN-STANDARD box car door rollers

Pre-lubricated and sealed GUIDEROL bearings are used in the door roller assembly shown here by the Pullman-Standard Car Manufacturing Company to assure ease of operation in spite of exposure to severe service conditions. Integral seals prevent infiltration of dirt and retain lubrication thus minimizing maintenance.

This roller arrangement was proved through test-application of over 75,000 severe individual roller and bearing impacts. Normal operation imposes loads of 600 pounds at 1.5 G's vertical acceleration.

Pullman-Standard also uses McGILL sealed GUIDEROL bearings in their P-S Compartmentizers, which consist of two pairs of strong steel gates dividing the box car interior into three flexible-size compartments. The gates roll smoothly on GUIDEROL bearing equipped rollers for easy, quick, one-man operation.



OLIVER tractors use GUIDEROL® bearings to provide long life

The Oliver Corporation employs a McGILL GUIDEROL bearing as the rear support for the power take-off shaft of its 660, 770 and 880 model tractors. The application is unusually demanding because of high fluctuating loads which may be applied by universal joints employed at an excessive angle, or by vee-belt or chain sprocket accessory drives. Oliver says the McGILL GUIDEROL has "long life, requires little maintenance, and will accept great loads." It operates at 540 rpm at a theoretical loading of 366 lbs. — greatly magnified by varying PTO attachments.

engineered electrical products

McGILL®

precision needle roller bearings

Send for free copy of McGILL Bearing Catalog No. 52-A.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette St., Valparaiso, Indiana

Looking for a new welded tubing source?

Ohio Seamless Tube is a "new" source in that we can now offer a wider range of welded tubing than ever before — even up to 7½ inches OD.

But there's nothing new about Ohio Welded Tubing *quality*. We're still making tubing with the know-how and experience gained in over half a century — the finest tubing made anywhere *bar none*. And we're unbiased in our advice because we make *both* welded and seamless tubing.

We can usually deliver Ohio Welded Tubing *fast* . . . always deliver Ohio Welded Tubing *to your exact specifications.*

Representatives in principal cities. Check: THOMAS', MacRAE'S, FRASER'S, SWEET'S FILE.

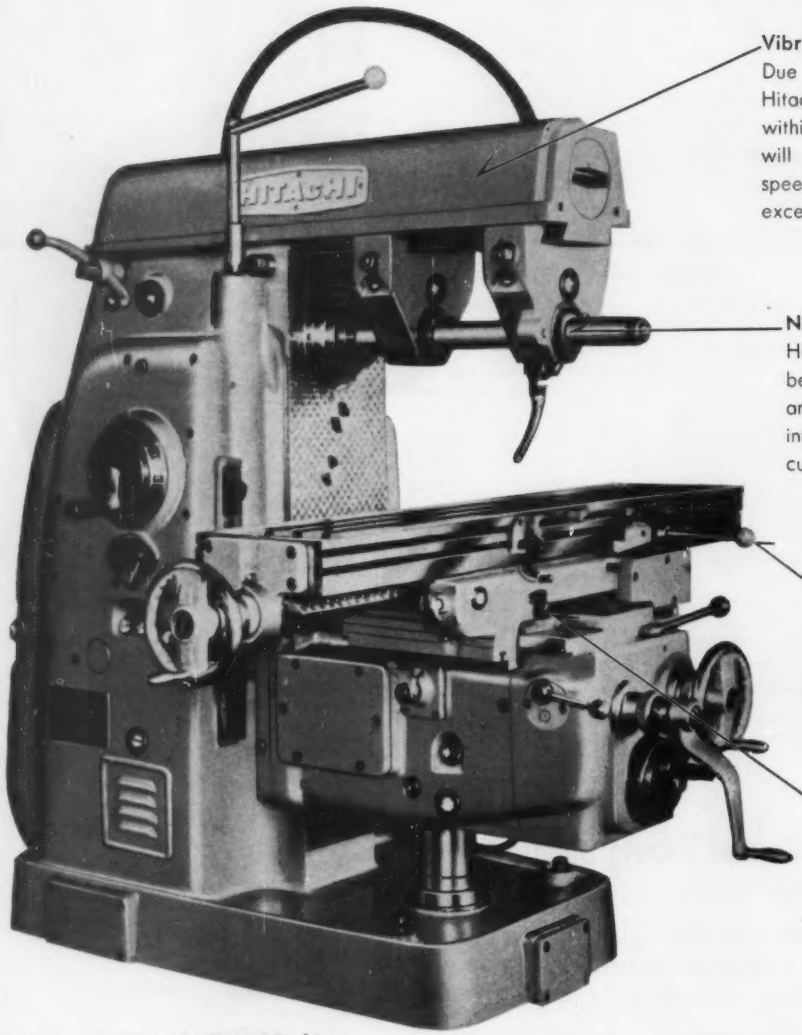
A-3234A

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • **SHELBY, OHIO**

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

HITACHI
NO. 2 ML MILLING MACHINES



No. 2 ML Plain Milling Machine

Vibration Damping Device
Due to a vibration damping device of Hitachi's exclusive design contained within the over-arm, minimum vibration will be set up even during higher speeds and feeds operation, so that an excellent finished surface is obtained.

New-Type Arbor Support Bearing
Hitachi's unique super precision-type bearing, a combination of plain metal and needle bearing, is incorporated into the machine to enable high speed cutting with high precision results.

Mono-Lever Control System
Hitachi's unique Mono-lever Control System makes the operation simple and easy. Table-feeding too can be performed with ease.

Backlash Eliminator of Lead Screw
As the use of two independent nuts eliminates backlash on the table feed screw, smooth down-cutting can be effected.

SPECIFICATIONS :

- 53 1/8"×10 1/16" Table
- 28" Longitudinal Traverse
- 16 Table Feeds 1/16" — 78 3/4"/min.
- 16 Spindle Speeds 25 — 1,500 r.p.m.
- 7.5 h.p. Main Motor

Hitachi, Ltd.
Tokyo Japan

Cable Address : "HITACHY" TOKYO

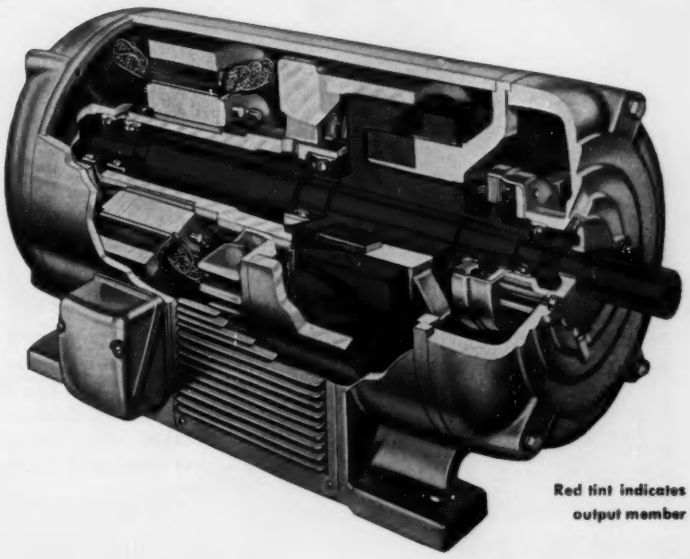
Circle 259 on Page 19

NOW— another FIRST by the Originator of Eddy-Current Equipment

NEW

DYNAMATIC®

Model 905 Ajusto-Spede® Drive



Red tint indicates output member

Extends Capacity Range to 15 HP in the Popular Quill-Type Design

The addition of the new model ACM-905 to the famous ACM-903 and ACM-904 lines of Dynamatic Ajusto-Spede Drives makes the desirable features of Dynamatic Quill-Type design available for many new applications.

Dynamatic Ajusto-Spede Drives provide controlled adjustable speed from an AC power source. Standard control features include on-off clutch control, infinite speed adjustment, constant speed regulation, and jogging. Any of a variety of special features may be easily and economically added to the standard control.

All Quill-Type models are available with either eddy-current, Dyna-torQ, or fail-safe brakes.

An Ajusto-Spede Drive, a control unit (either electron tube or transistorized magnetic amplifier), and a push-button station comprise a compact, easily installed, low-cost drive package.

Check these Ajusto-Spede® Advantages

- ★ Infinitely adjustable speed from AC power
- ★ Simplified construction
- ★ Compact design
- ★ Wide speed range
- ★ Remote control
- ★ Stationary field coils
- ★ Excellent performance characteristics

Send for Illustrated Descriptive Literature

EATON

DYNAMATIC DIVISION

MANUFACTURING COMPANY

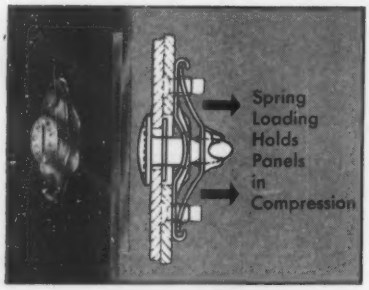
3122 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Quick-Opening Fasteners

Selecting Small Fastenings for Metal Closures

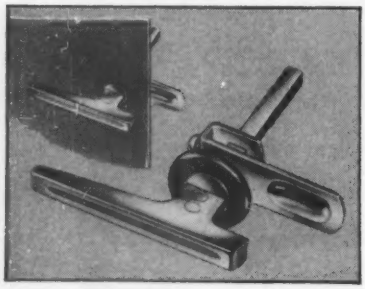
*"Use captive fasteners wherever feasible . . . Avoid the use of loose washers and loose nuts . . . Fasteners on equipment covers should be operable either with no tools or with standard hand tools"**

(John D. Folley, Jr. & James W. Altman, Research Scientists, American Institute for Research)



Quarter-Turn Fastener

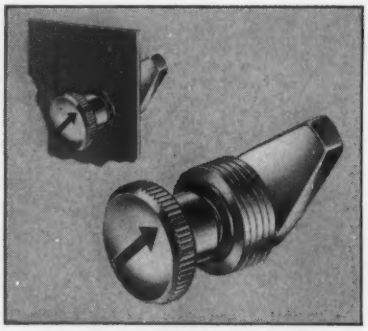
Lion Fasteners open and close with a ¼ turn, hold sheets tightly under the compression of a rugged spring. Quickly operated and fully retained in the outer panel, they are approved under U. S. Government military specifications. Stud and receptacle float for easy alignment and simplified hole preparation. Flush, oval, wing, knurled, ring, and key head styles available. Sizes—No. 2, No. 5, and High Strength for extra heavy duty.



Cabinet Latch

Just drill a hole, push the fastener stem through, and slide the special push-on clip into place. No welds, screws, bolts or rivets: the fastener is permanently installed in seconds!

Adjustable to any grip length or panel thickness, the pawl is fixed in place by a single set screw. The fastener's brightly finished knob is set off by a plated washer. Also furnished with screwdriver operated flush head.

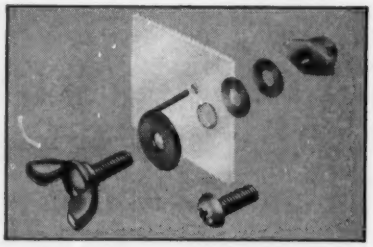


Spring Tension Latch

For fastening slide-out drawers and hinged panels the Southco Arrowhead Latch is recommended. It locks or opens with a quarter turn yet occupies less than ½" inside space.

Doors are held under spring tension—a push against the arrowhead knob relaxes this tension, allows operation with fingertip ease. Drill a single hole for installation—no fastening to the door is necessary. No striker plate is needed.

Pawl stop is eliminated—arrowhead shows at a glance exact position of pawl.



Adjustable Panel Latch

Small doors and panels can be fastened with greatest speed and lowest cost with the Southco Adjustable Latch.

The entire fastener is quickly installed through two holes punched in the door; no bolts or rivets are needed.

It operates with a quarter turn, requires no striker plate. An extra twist after the nylon pawl is engaged pulls up the door to form a seal and eliminate vibration.

Available with wing, knurled, or Phillips head.

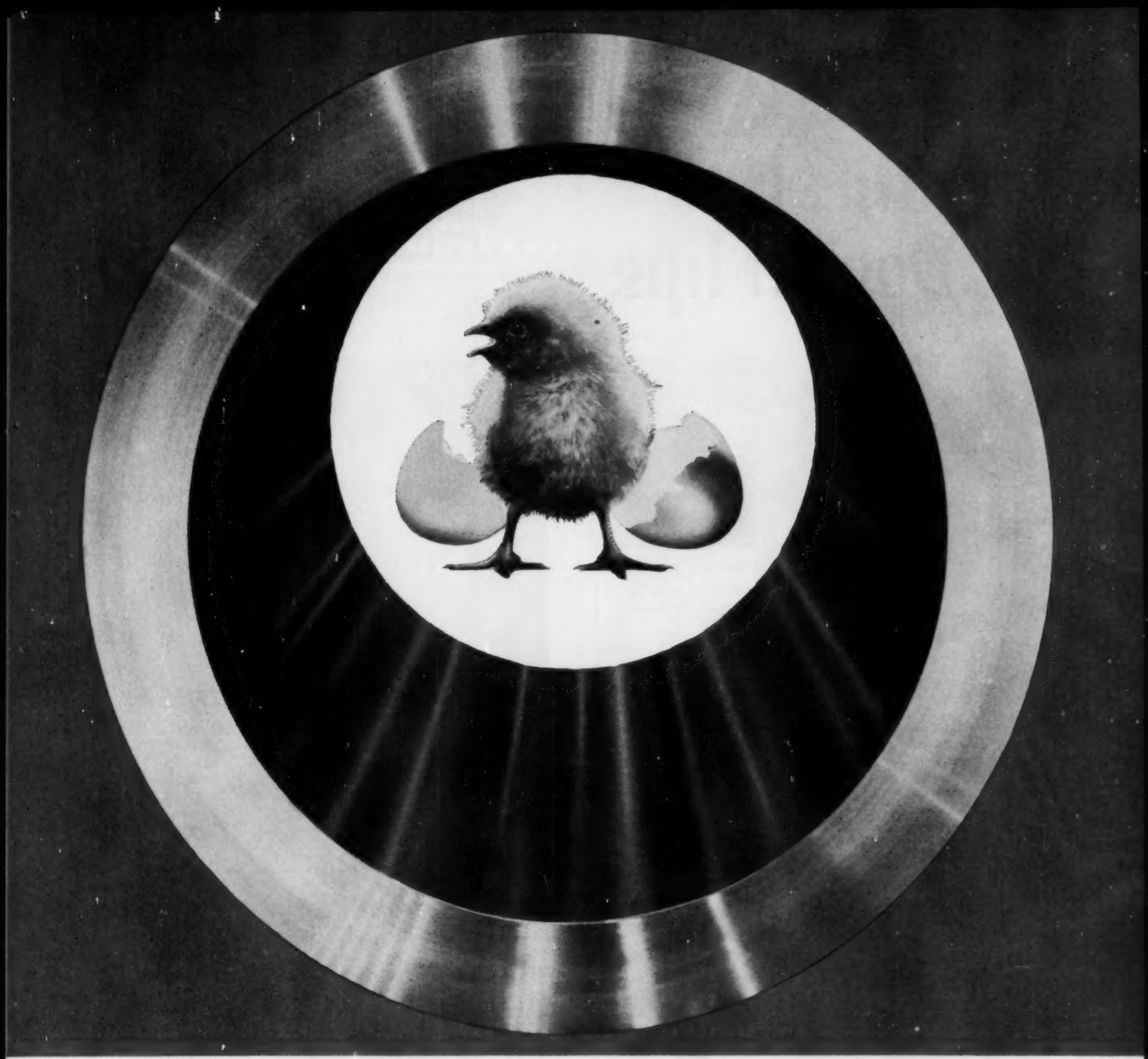
Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Gives complete engineering data on these and many other special fasteners.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

* *Quotation from "Designing Electronic Equipment for Maintainability"; Machine Design, July 12, 1956.*

SOUTHCO FASTENERS
LION



WHAT'S NEW IN TUBING?

Here's another ACIPCO "first"... ACIPCO CERAM-SPUN®, the ceramic mold process* that offers greater versatility in design, new concepts in economy.

WHAT THESE ADVANTAGES MEAN TO YOU! ACIPCO is not limited by equipment sizes. Now, for the first time, you can order the exact tube O.D. you need... from 2.25" to 50". As-cast lengths can vary from 4 feet to 20 feet, longer lengths are made by welding; and wall thicknesses range from .25" to 8". Furthermore, these tubes can be furnished with the exact combination of physical, chemical, and metallurgical properties required by your specifications.

THE RESULT: YOU SAVE MORE! No more unnecessary metal waste or excessive machine charges.

Too, ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — eliminate the delays and additional high costs often involved in buying from multiple sources. Before you order another steel tube... first investigate the many advantages ACIPCO offers. Contact ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

*Patent applied for

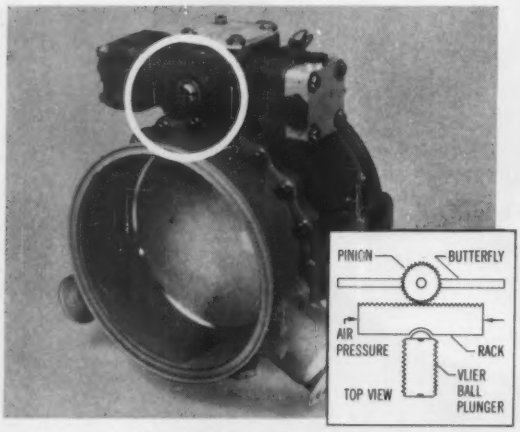
ACIPCO CERAM-SPUN®
STEEL TUBING

Circle 262 on Page 19

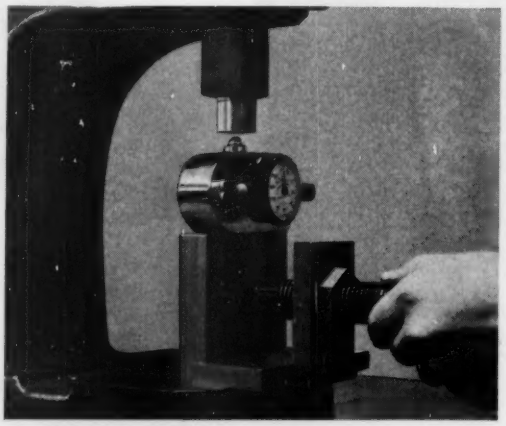
Practical Design Tips

No. 6 of a series

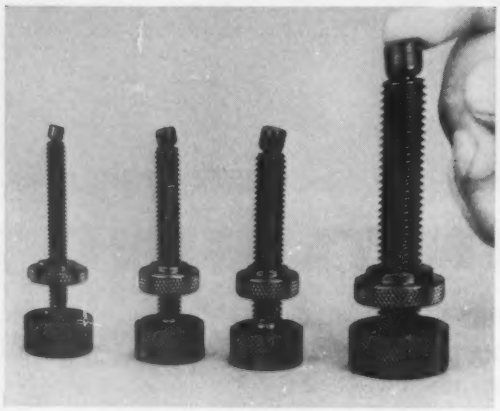
If the profit squeeze is making you look for new ways to reduce costs, look into Vlier products such as those shown below. Hundreds of companies are using these simple, standard parts to replace complicated, specially-machined devices—usually at a fraction of the cost.



SPECIAL VLIER BALL PLUNGER used on this Hermetic Barrier Valve detents on a rack which controls a pinion, which in turn, operates the butterfly. Air pressure forces rack out of detent, opening or closing valve. Plunger, therefore, acts as a positive stop until air pressure is great enough to force shaft past detent. Vlier Ball Plungers are available as standards in sizes from 4-48 x 3/16" to 5/8-11 x 1". Various end pressures. Specials on quantity orders.



SPECIAL VLIER SPRING PLUNGER, shown in test fixture, has laminated phenolic plunger to conform to MIL-P-79B (Type GMG). 1¼" plunger travels .890"; absorbs side load of 105 ±20 pounds. Vlier can provide spring-loaded devices with various diameters, end pressures, plunger lengths, and made of materials to meet your specifications.



NEW CONTROLLED-TORQUE TOOL incorporates a swivel-pad on the screw end to protect surface of part being held. Pad swivel 7½° in all directions to accommodate off-angles. Has unique ball-joint construction for smooth operation. Named the Vlier Torque Thumb Screw Swivel-Pad Clamp, they are available as standards in ¼-20 x 2¼", 5/16-19 x 2¼", 3/8-16 x 2¼" and ½-13 x 3".

FREE IDEA BOOKLET—16 pages crammed with photographs showing how others have profited by designing standard Vlier parts into their products. Your Vlier distributor will be pleased to give you a copy, or if you prefer, write directly to us.

VLIER
Engineering Corporation
A subsidiary of Barry-Wright Corporation
8900 Santa Monica Blvd., Los Angeles 46, California

Circle 263 on Page 19

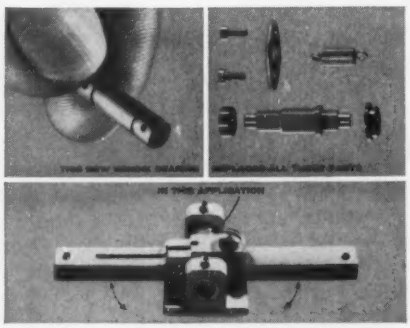
Circle 264 on Page 19

NEW FROM BENDIX!
THE FREE-FLEX PIVOT BEARING

Positively no friction or backlash... requires no lubrication

It's the Bendix Flexural Pivot. Made of pairs of flat, crossed springs, the new Bendix® Free-Flex Pivot Bearing is completely free of friction and backlash—and eliminates the need for lubrication. This compact, integrated unit is easy to install, easy to use. And its performance is consistency itself.

Bendix Free-Flex Bearings come in two types. The Cantilever type for supporting overhung loads. The double-end-supported type for bridge-supporting a central load. Both are corrosion-resistant steel. Both have high lateral and radial rigidity plus low torsional rigidity.



Before Free-Flex, this air data sensor component had six parts, requiring machining tolerances of .0003". With Free-Flex Bearing, the closest tolerance required is only .005".

Our first low-cost standard models come in 3/16", 1/4", 3/8", and 1/2" diameters with three deflection limits: ±30°, ±15°, and ±7.5°. Fast delivery of any of our 24 standard combinations. A little longer if you require a special type. We'll be glad to send you details and prices on request. Write today.

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THE Bendix CORPORATION

DESIGN
April 27, 1961

The Technical Scrapheap

TECHNICAL progress today is phenomenally fast. Everyone is familiar with this fact and calmly accepts it.

But this accelerated pace in science and engineering can be painful—and perhaps disastrous—for some of the people involved.

For instance, consider aircraft power plants. For about forty years, piston engines were the prime target of research and development. On coming out of college, an engineer could settle into a career of specialization in aircraft piston engines with a reasonable assurance that he was "set" for life.

Then, during World War II, lightning struck. Almost overnight, the emphasis changed from piston to jet engines. People with an established career found themselves on the technical scrapheap. Result: A scramble to acquire the new knowledge demanded by jet-engine engineering and research.

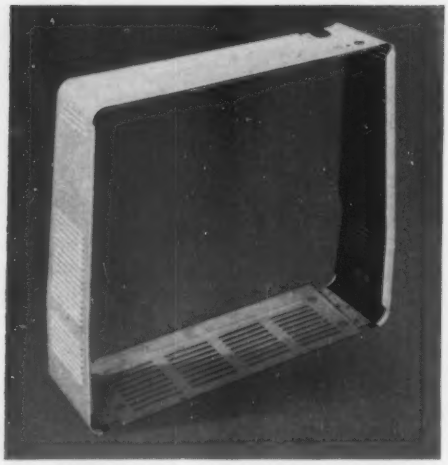
About a dozen years later, liquid and solid-fuel rocket engines moved into the limelight and, a few years after that, electric propulsion and other exotic methods. Keeping up has meant disruption in the careers of scientists and engineers.

For an individual engineer working in such advanced areas as aircraft and missiles, electronics, and data processing, this "collapse of time" has already been felt. In these fields, an engineering career can involve two or three major career changes in a lifetime.

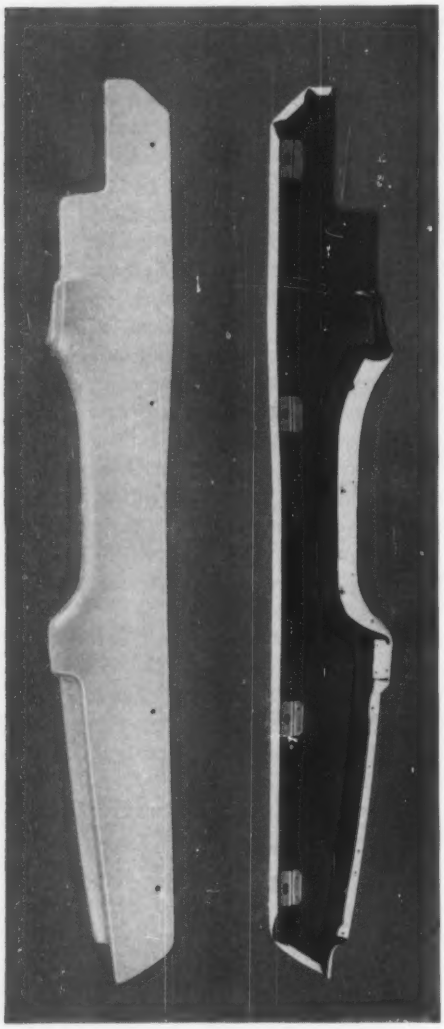
What's the answer? One obvious solution: Constant attention to new developments—not only in one's own field, but in related fields. Also, an engineer may never really stop "going to school."

You may never be confronted with the problem. But who can forecast whether any branch of engineering—even the most comfortably static—will remain immune?

Robert L. Stedfeld
MANAGING EDITOR



Portable TV cabinet body of durable and attractive vinyl-steel laminate is stamped and formed on standard equipment.



Transmission cover for 1961 Thunderbird requires the durable, scuff-resistant surface of a vinyl-steel laminate. Welding of brackets to rear surface, right, does not affect vinyl film.

Designing with

Vinyl-Metal Laminates

JAMES K. BAKER
General Manager, Arvinyl Div.
Arvin Industries Inc., Columbus, Ind.

VINYL-METAL laminates offer a combination of physical and aesthetic properties rarely found in a single material. These characteristics include formability, resistance to abrasion and chemicals, structural strength, and the availability of embossed or printed surfaces in any choice of color. Vinyl-metal laminates are used for such applications as office-machine housings, automotive instrument panels, and radio and TV cases—products that require a durable, scuff-resistant, easily cleaned finish.

This article considers design factors involved in the selection of vinyl thickness, finish, and color, and presents solutions to common problems of welding vinyl-metal-laminate assemblies.

Vinyl Materials

Polyvinyl chloride, in the form of semirigid, calendered film, is the most commonly used vinyl material for lamination to metals. Although the formulation varies from that of floor-tile vinyls, the high-durability characteristic of the base resin is retained.

Thickness: PVC film thicknesses in the vinyl-metal laminates range from 0.004 to 0.014 in. with most uses in the 0.008 to 0.012 in. range. The primary consideration for selecting a film thickness for a particular application involves the amount of forming and crimping in the finished part. Films 4 to 6 mils thick can be drawn deeply if the corner radii are sufficiently generous, but these thicknesses generally are not recommended for parts with severe

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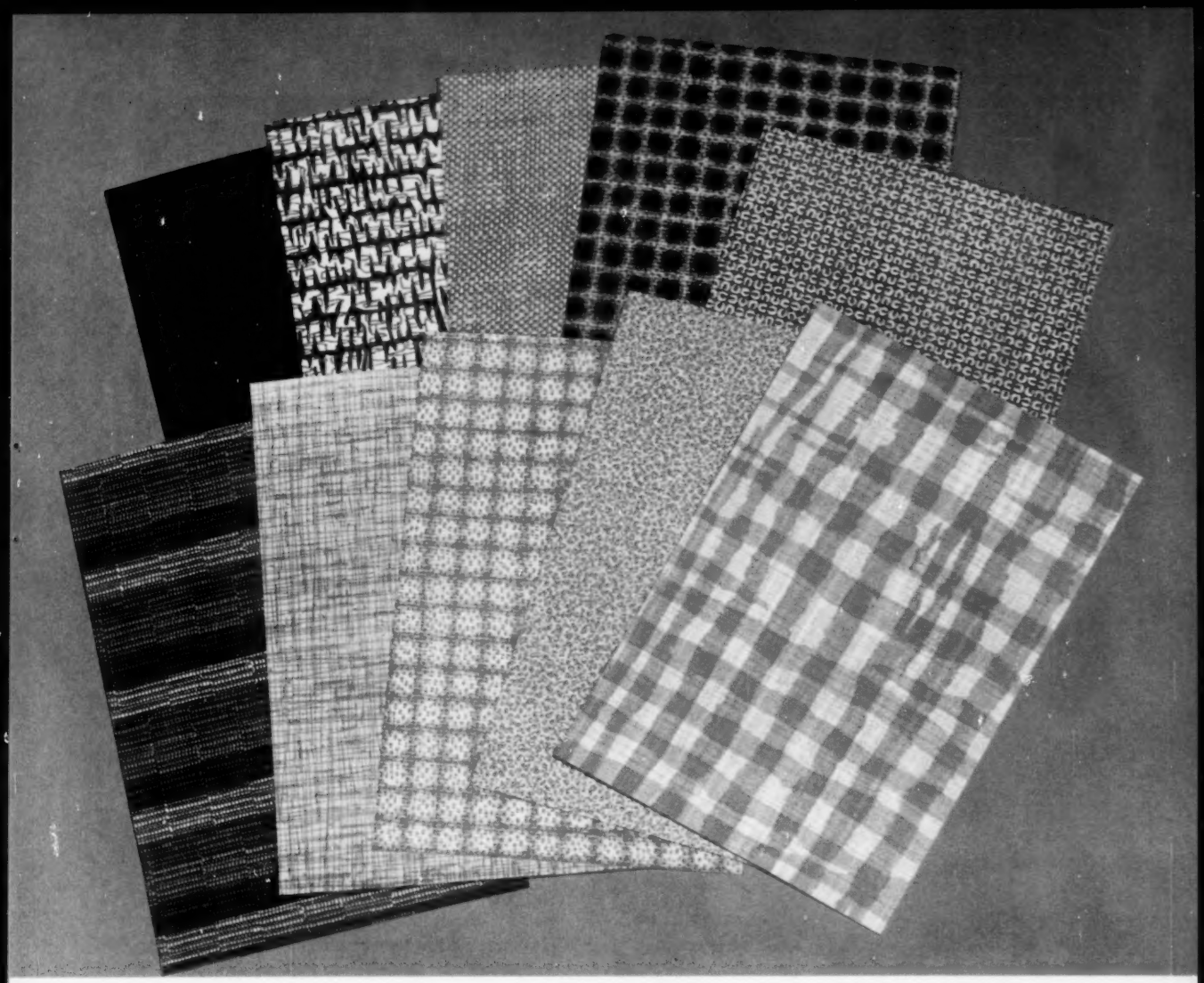


Choice of printed patterns, colors, and embossed surfaces is almost unlimited in vinyl-metal laminates.

draws or with lock seams or hems. These light-gage films do not have the body to withstand such fabrication operations and still maintain the degree of durability normally required in the finished part.

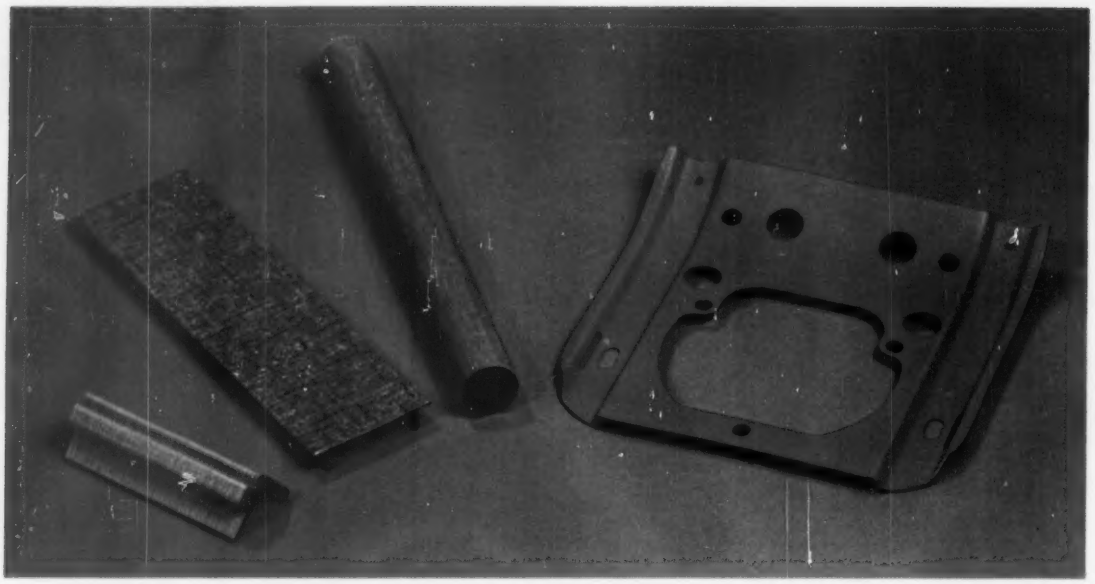
A second factor in determining film thickness is the amount of emboss desired on the finished part. Generally, 20 to 30 per cent of the emboss of a film is ironed out in the lamination process. Thus, the loss in emboss of 0.004 and 0.006-in. films is apparent during lamination; the emboss in 0.010 and 0.012-in. films remains distinct.

Another factor in establishing film thickness for a vinyl-metal laminate involves material cost. As a rough rule, 1 cent per square foot can be saved for every 0.002-in. reduction in the vinyl thickness. Therefore, the economies of using plain-colored, light-gage vinyl films should not be overlooked for applications that do not require severe forming and whose appearance does not demand a highly embossed surface.

Emboss: Although rough and smooth finishes are nearly equal in durability, a highly embossed finish hides minor scratches or abrasions on the surface, and small dents in the substrate material. Smooth vinyls show these marks, particularly if the film has a high-luster finish. For this reason, relatively few vinyl films are produced with unembossed finishes.

Surface Finish: Various top coatings can be applied to give the vinyl film a dull matte finish, a medium luster, or a bright gloss. These finishes are commonly referred to as "luster-control" coatings. Generally, dull coatings are applied to leather and wood prints, and medium or bright toppings are used on metallic or gaily colored films.

Other than luster-control coatings, any of several other top coatings are used to add durability to the laminate. On printed vinyls, a 0.002-in. clear protective coating can be applied for maximum protection of the printed surface. For a light protective coating over the printed pattern, a clear coat or solution clear coat can be used. These coatings are less than 0.0005 in. thick and are adequate for products which are subjected to moderate abrasion.



Roll-formed parts, left, and lock-seam tubing, center, of vinyl-steel laminates are produced on standard equipment at 100 fpm or more. Heater bracket, right, is representative of vinyl-steel stampings.

Vinyls with a special stain-resistant coat are particularly suitable for kitchen and hospital products.

Some coatings are used in combinations. For example, a dull luster-control coating can be applied over a 0.002-in. clear coating, thus providing both maximum abrasion resistance and a dull matte finish. Generally, unprinted vinyls are used without a coating of any kind.

Printed Patterns: Vinyl films are produced in hundreds of pattern and color combinations. Like embossed surfaces, printed patterns hide surface mars that may occur during handling or use of a product.

Printed patterns with straight lines are not always desirable on parts which will be deep drawn, because of pattern distortion. However, in some instances, the distortion creates an interesting effect.

Either printed or plain-colored vinyl-metal laminates often show "piping" when subjected to 180-degree hems. This lightening effect is particularly noticeable on tight hems of dark-colored vinyls. Piping is the result of the pigment becoming less dense in the elongated area. Light shades of vinyls also produce piping, but here the effects are usually not visible.

PVF Films: A relative newcomer in the vinyl-metal laminate field is Du Pont Teslar (polyvinyl fluoride) film. PVF laminates are particularly suited for outdoor applications. This film is highly impervious to moisture and resistant to chemicals and atmospheric discoloration. PVF is recommended as a finish for steel in applications where the part is subjected to severely corrosive conditions for extended periods. The film provides an almost permanent barrier to the elements, even when used in a thickness of only 0.002 in. Properties of PVF film are shown in Table 1.

Most present applications of PVF-metal laminates are in building panels and billboard trim, but other items such as machinery housings and vending-machine cabinets are being actively considered.

Adhesives: The combined effects of many variables must be considered in selection of an adhesive for bonding the vinyl to the metal. These variables include: 1. Vinyl formulation. 2. Vinyl thickness. 3. Metal gage. 4. Surface requirements. 5. Manufacturing operations. 6. Environment of end product.

Thermosetting adhesives are generally, but not always, used for panel-type products; thermoplastic adhesives, usually for drawn products.

Adhesive science has kept pace with the special-

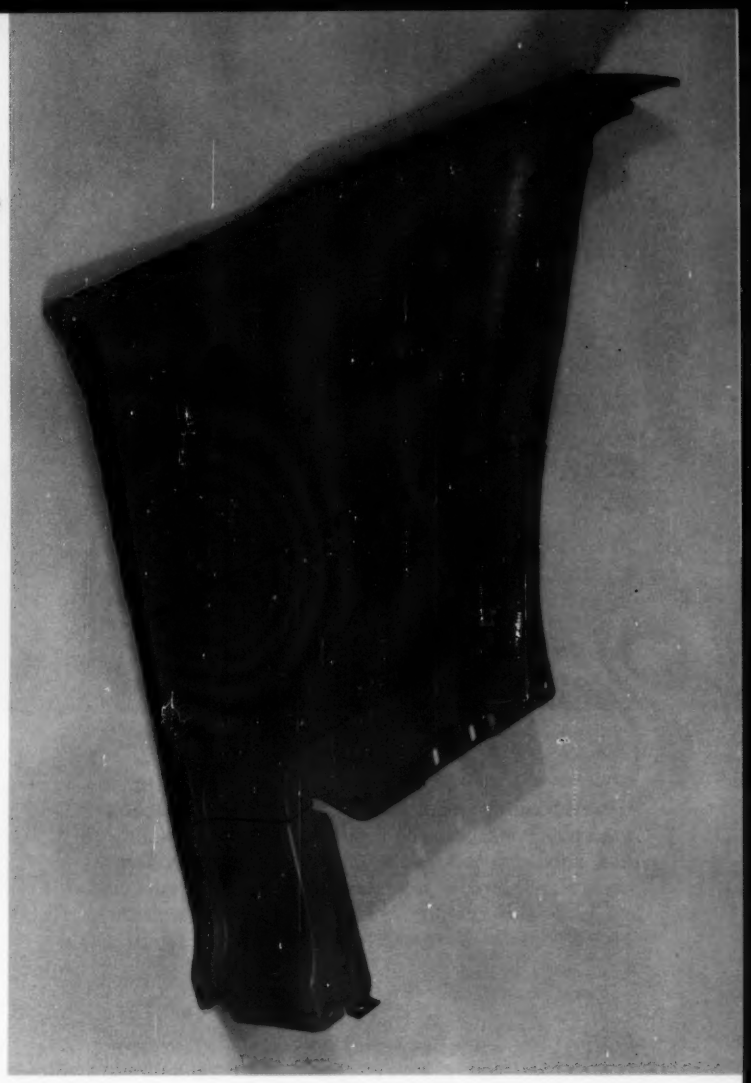
Table 1—Properties of PVF Film

Tensile strength, psi	13,000
Elongation, per cent	150
Modulus of elasticity, psi	320,000
Impact strength, kg-cm per mil	5
Flex life, cycles	70,000
Abrasion resistance (ASTM D658-44), min per mil	4–6
Tabor abrasion, dry, mg per 1000 cycles	23
Chip resistance (ASTM Bulletin 200), cm per sec	65
Dielectric strength, v per mil	3000

Table 2—Standard Sizes of Vinyl-Metal Laminates

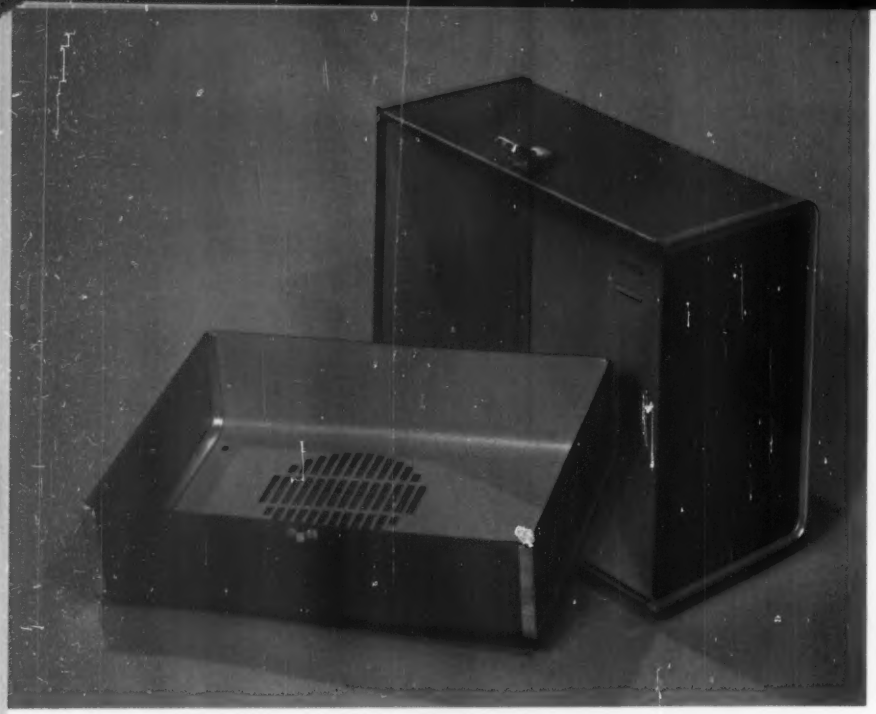
Metal	Thickness (in.)	Width (in.)
Steel		
Cold rolled	0.0120-0.0598	50
Galvanized	0.0149-0.0516	50
Aluminized	0.0186-0.0430	50
Tin plated	0.0149-0.0239	34.5
Aluminum	0.015-0.063	50

Three vinyl-steel laminate parts form welded rear wall-panel assembly for 1961 Thunderbird. Spot welds joining top two components are covered later by arm rest. Color and grain of vinyl film matches vinyl upholstery throughout car.



Lightweight housing for movie camera utilizes the attractive and durable finish of embossed leather-grain vinyl film laminated to aluminum base.

Lid for 1961 phonograph housing is formed from a double-vinyl laminate—vinyl film on both sides of a steel base. A vinyl extrusion protects the edge and eliminates chatter during operation. Body has a vinyl film on the outside only.



Two-tone slide-projector case utilizes Aluma-lok corner design to attach vinyl-metal laminate end panels to wrap-around components. Design eliminates almost all trim scrap in fabrication.

nature bonding requirements of current products. For example, bonds can be made to withstand plating and anodizing treatments after lamination. Or they can be subjected to secondary drawing operations or to high temperatures. The vinyl-metal laminate can essentially be considered as a single material.

Metals

Vinyl films are laminated to cold-rolled steel of commercial and drawing qualities, to galvanized, electrolytic zinc, and aluminized steels, to all alloys of aluminum, to electrolytic and coke tinplate, and even to stainless steel and magnesium. Table 2 shows the available size range of some of these metal-vinyl laminates.

Because of the corrosion resistance of the vinyl film, the metal specification for a given part can often be revised to use a lower cost substrate material. For example, a part originally made of 0.040 in. aluminum might be made of 22-gage steel (0.0299 in.) plus a 0.010 in. vinyl film. The part retains the same approximate over-all thickness.

Forming: Vinyl films compress somewhat during forming operations, and some authorities suggest allowing for a 40 per cent compression of the film when calculating die clearances. This practice is not recommended, however; over-all thickness of the laminate should be considered as the effective metal thickness.

Ordering metal in standard gage thicknesses may not always be the most economical practice when moderate to high-volume production is involved. Specification should always include consideration of mill orders of nonstandard thicknesses.

Cleaning: Mill steel has a slight surface smudge which is not completely removed by the usual metal-cleaning processes. The additional cost of specially cleaned steel from the mill is negligible. A clean surface is necessary for a high-quality permanent bond of the vinyl to the steel. Warehouse-quality steel is usually unsuitable for lamination.

Table 3—Effect of Outdoor Exposure on PVC Colors

Color	Rural Test Site, 10 months	Industrial Test Site, 10 months
Green	A	A
Turquoise	A	A
Standard blue	B	C
Special blue	A	A
Tan	A	A
Red	C	D
Black	A	A
White	A	A
Light green	C	D
Gray	B	C

A=No fade; B=Slight fade; C=Moderate fade; D=Extreme fade.

Assembly

Many techniques have been developed for assembling vinyl-metal laminates. Some use standard fabrication machinery; others require specialized equipment.

Mechanical: Vinyl-metal laminate shapes can be roll formed and tubular sections lock seamed on standard equipment at normal operating speeds.

Corner-locking systems, usually proprietary, require small presses to dimple an extruded metal shape into the adjoining panels.

Welding: New welding techniques permit assembly of vinyl-metal products without damage to the film surface. With these methods, brackets, clips, or studs can be welded to the metal side of the laminate with no need to subsequently mask the areas with trim strips or other devices. Design details of several techniques are shown below.

Future

Outdoor applications for vinyl-metal laminates are increasing rapidly. Color fading after several months of exposure to sunlight and outdoor elements is negligible with colors such as green and turquoise; fading of some colors, however, precludes their use for such applications at this time, Table 3.

Vinyl films with finishes resembling stainless steel, anodized and brushed aluminum, and chrome are currently being developed for lamination on steel. Currently, many bright-metallic finishes are available in laminates, but bright-chrome imitations with hard surfaces are still products of the future.

It is expected that the market will demand laminates for even more varied and versatile applications—films that will endure 30 years of outdoor exposure, or that will withstand temperatures over 500 F. These severe environmental conditions extend the challenge for tomorrow's laminates.

Techniques for Welding Brackets, Studs, and Body Joints for Vinyl-Metal Laminate Parts

(Vinyl films are shown in heavy black line)

(a)

PROJECTION WELD CLIP (series weld)

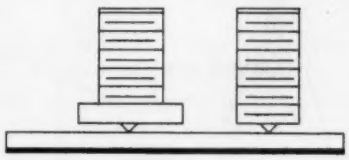
Best suited for attaching clips, stiffeners, and brackets to metal side of vinyl-metal laminate. Weld is strong and does not damage vinyl surface.

(b)

STRAIGHT PROJECTION WELD (series weld)

Similar to *a* except that the projection is formed in the laminate and the vinyl material is ground or brushed from the projection to produce a metal-to-metal contact. Weld does not damage outer vinyl surface.

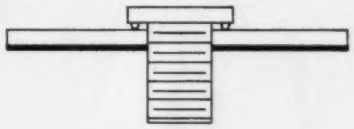
(c)



STUD WELD (series weld)

Used to attach studs for subsequent assembly of trim or stiffener members. Weld is strong and does not damage the vinyl film.

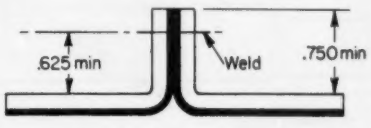
(d)



STUD WELD (series weld)

A modification of *c* to extend stud through the laminate on the vinyl side. Because the weld can damage the vinyl material, this arrangement requires a trim or other component to cover the weld area.

(e)



BODY-JOINT WELD (direct-shunt weld)

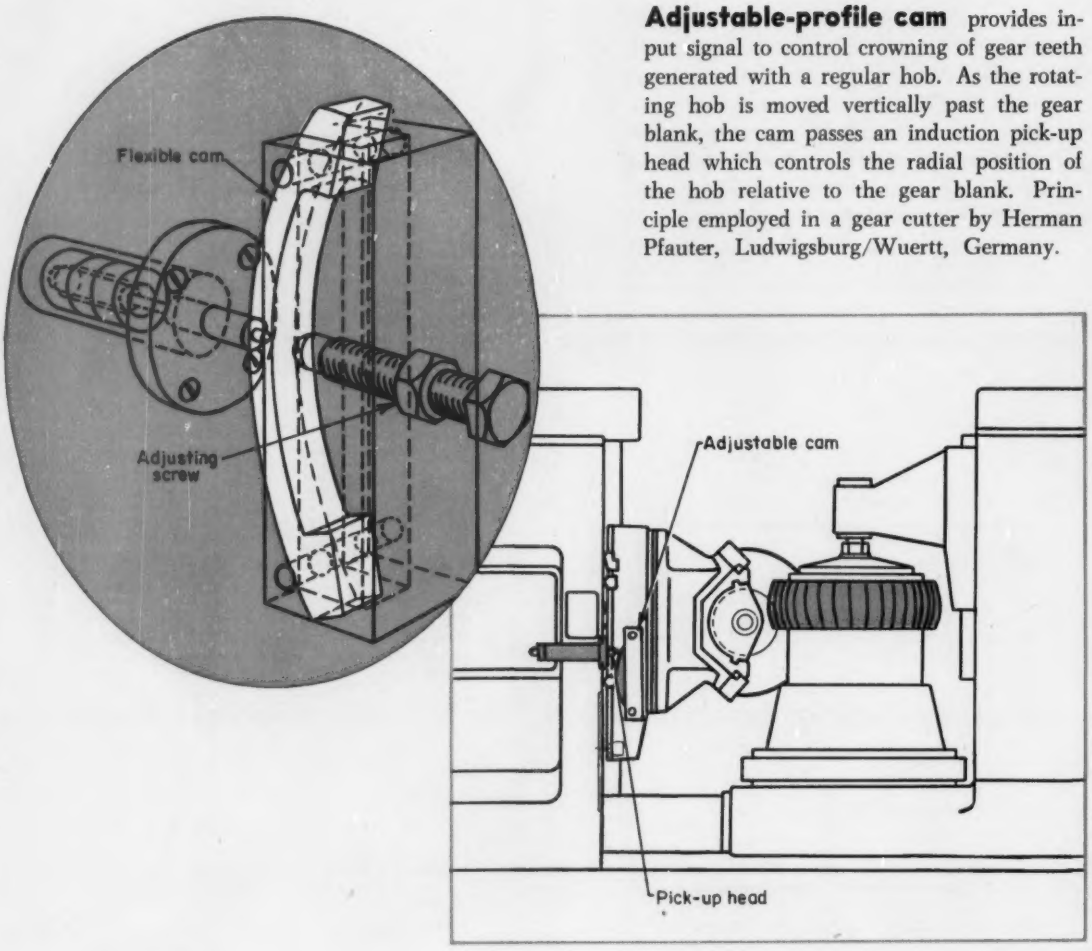
Used to join panels in an assembly. Welding damages the vinyl film in flange area but with proper design (as shown), the exterior vinyl surfaces are not affected.

(f)

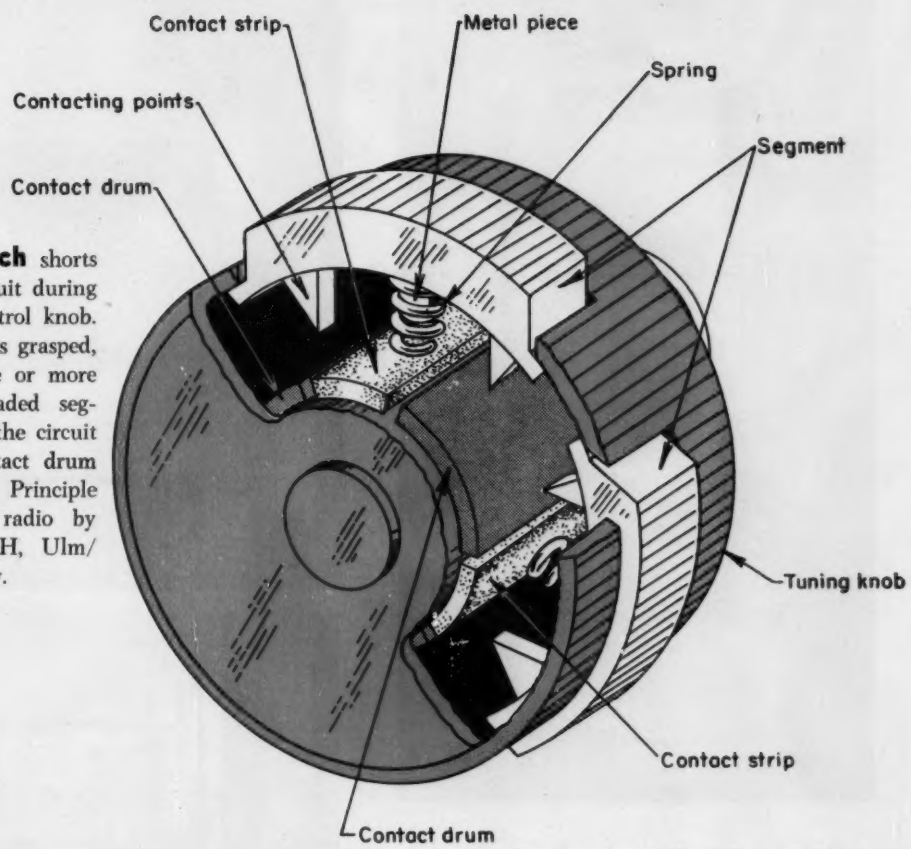
BODY-JOINT WELD (direct-shunt weld)

Used instead of *e* for economical panel joint when stiffness is not critical and when damaged vinyl surface will be covered by trim component.

scanning the field for *ideas*

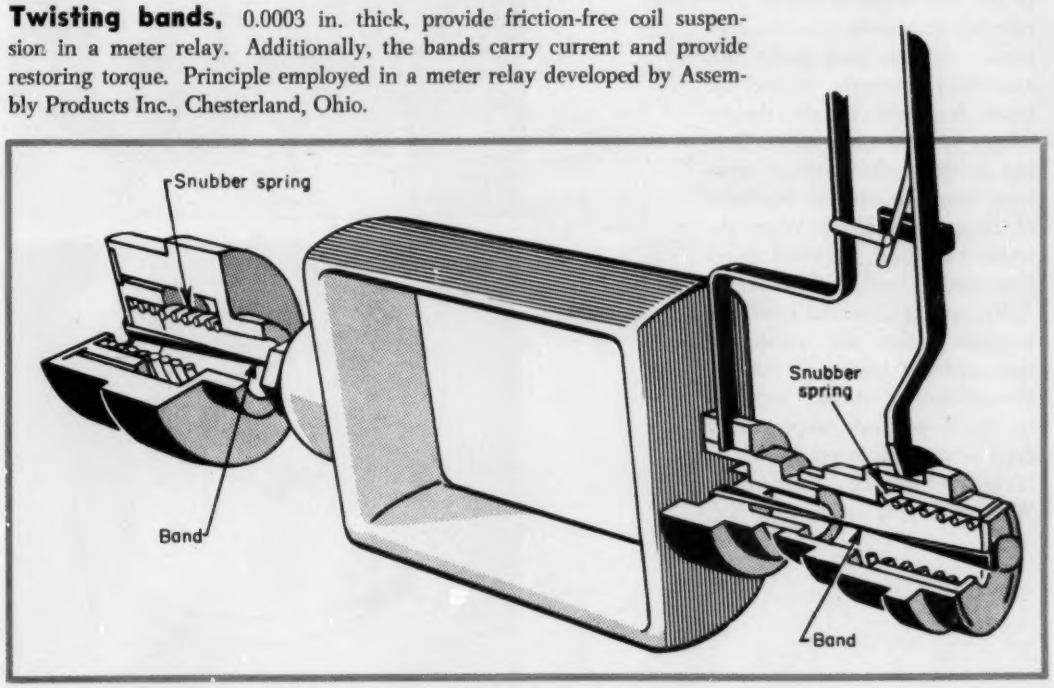


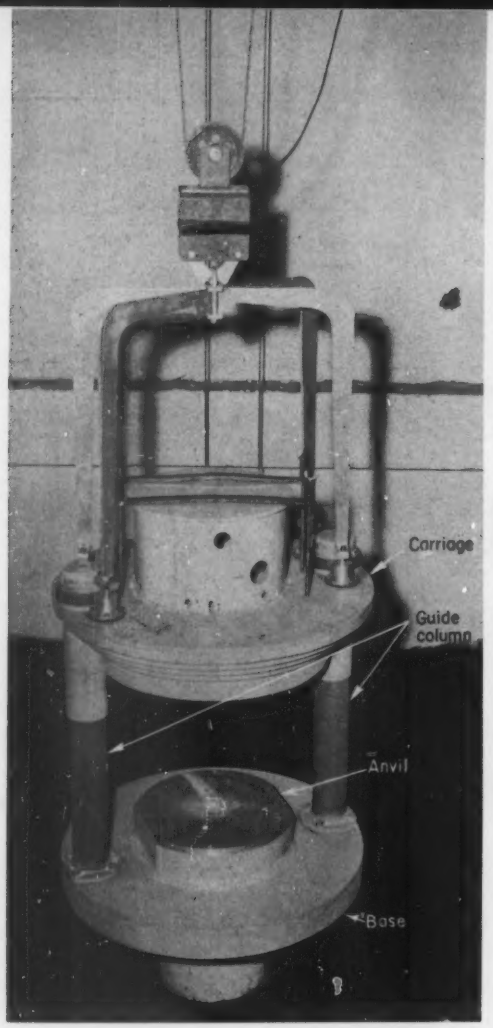
Adjustable-profile cam provides input signal to control crowning of gear teeth generated with a regular hob. As the rotating hob is moved vertically past the gear blank, the cam passes an induction pick-up head which controls the radial position of the hob relative to the gear blank. Principle employed in a gear cutter by Herman Pfauter, Ludwigsburg/Wuertt, Germany.

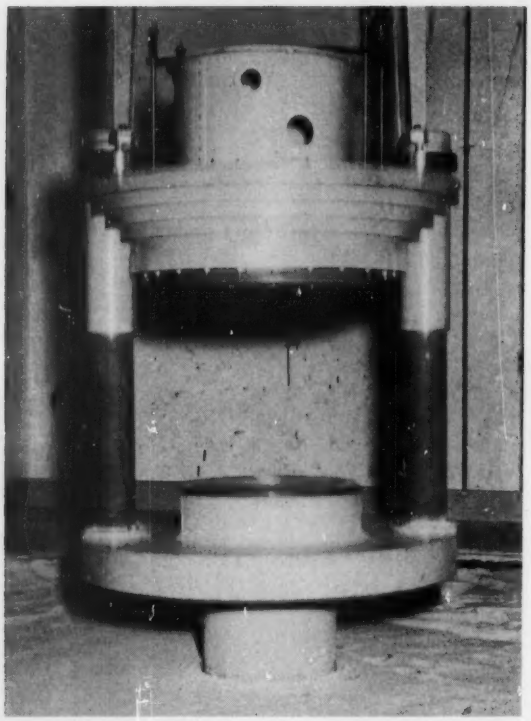


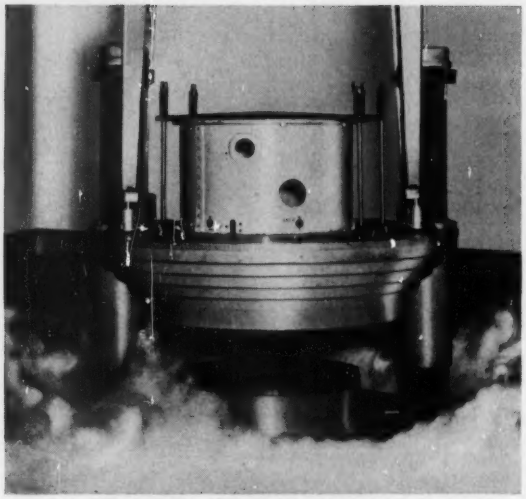
Squeeze switch shorts out auxiliary circuit during rotation of a control knob. When the knob is grasped, depression of one or more of the spring-loaded segments completes the circuit between the contact drum and contact strip. Principle employed in a radio by Telefunken GmbH, Ulm/Donau, Germany.

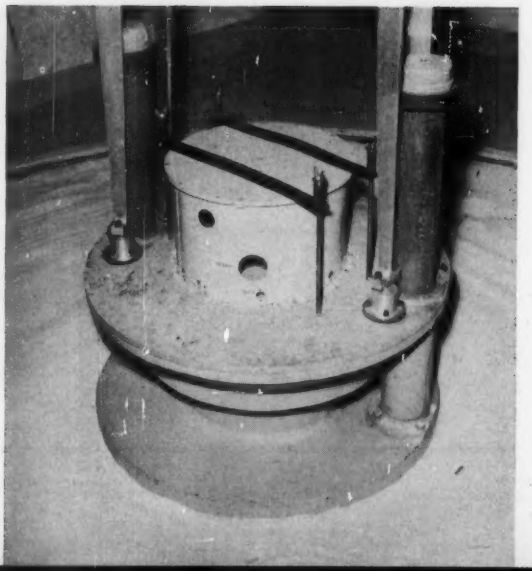
Twisting bands, 0.0003 in. thick, provide friction-free coil suspension in a meter relay. Additionally, the bands carry current and provide restoring torque. Principle employed in a meter relay developed by Assembly Products Inc., Chesterland, Ohio.



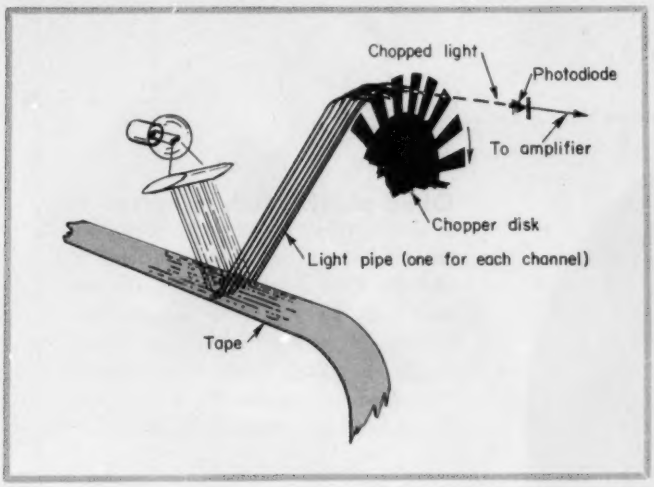






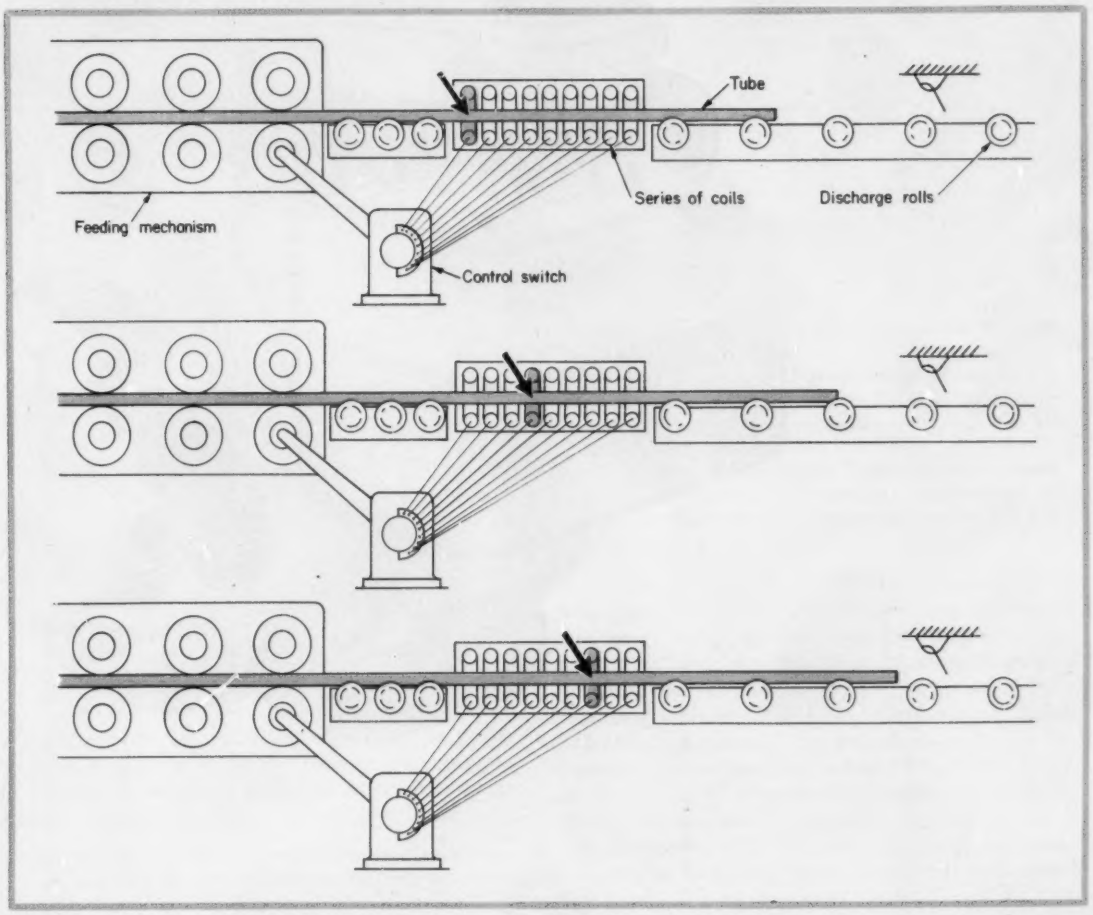


Quick - sequence landing of the two major elements in a portable drop tester provides high impact without long guide rails and bulky structures. In use, the tester is raised to the desired height by a hoist or a crane. During hoisting, the carriage separates from the anvil to the limits of the guide columns. When the tester is dropped, the anvil strikes first, imbedding itself in sand. A fraction of a second later, the carriage strikes the anvil and transmits the impact to the test component. Principle, reported by V. F. DeVost, employed in drop tester developed by U. S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.

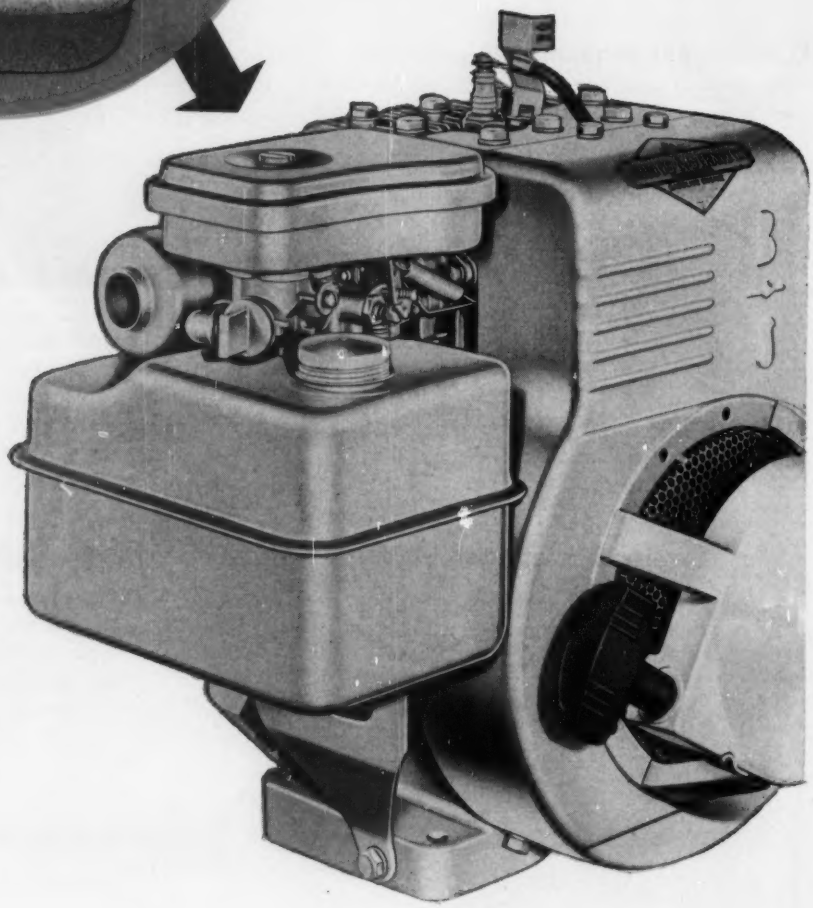


Chopped reflected light detects presence or absence of signal, whether tape is punched or printed, opaque or transparent. In the absence of perforations or printed code, the light reflected from the tape is mechanically chopped by a rotating disc. Thus, the sensing photodiodes generate an alternating current. Any data, punched or printed, on the tape prevents corresponding reflection, thus producing a signal in the detection circuits. Principle employed in tape reader by Omnitronics Inc., Philadelphia, Pa.

Coil-current sequence is synchronized to tube speed in a rolling mill to provide localized heating for cut-off of tube. The rotary control switch is operated by the feed-control mechanism. Principle employed in a rolling mill designed by Schloemann AG, Duesseldorf, Germany.



Oiled plastic foam filters air in a small-engine air cleaner. Since all the oil is held on the cell surfaces of the Du Pont urethane foam, the engine may be tipped to any position without impairing filter action. Filter media, by Scott Paper Co., Chester, Pa., used on engine by Briggs and Stratton Corp., Milwaukee, Wis.



Keeping up with TECHNICAL LITERATURE

50,000 technical publications come off the world's presses each year. Despite this formidable flow, an effective reading program can be achieved through a plan of selected periodical reading supplemented by use of abstracts and indexes.

HAROLD S. SHARP
Technical Librarian
AC Spark Plug Div.
General Motors Corp.
Milwaukee, Wis.

REPORTS of improvements, discoveries, and scientific developments come off the presses in a steady stream. It is estimated that more than 50,000 technical publications are printed per year throughout the world.

It is obviously impossible to read all publications, or even all those which pertain to a particular field of interest. Hit-or-miss reading is little more than a waste of time, but reading done selectively can be of inestimable value. By the application of various selection techniques it is possible to read pertinent periodical and other articles without scanning a mass of irrelevant material.

Selective Reading Plan

To achieve a plan of selective reading, particular fields of interest must be determined. For example, an engineer involved in design of automobile transmissions might have several information needs:

- Being fully informed on the latest engineering methods and data on gears, shafts, clutches, bearings, and similar mechanical elements. For this purpose, he may read technical magazines emphasizing this area of engineering.
- Keeping in touch with general developments in the automotive industry. Perhaps a business type of publication specializing in automotive news might be his answer.
- Being aware of new scientific developments on a broad front for possible application in transmissions. A scientific news periodical might be reviewed for this purpose.

By contrast, articles or periodicals having to do with electrical starting systems, painting techniques, or styling might take on secondary importance. If time is limited, reading must be concentrated in primary fields of interest.

Having defined these fields, the particular publications which contain the desired coverage are determined. In this task, contacting a literature specialist is helpful. If a company maintains a technical library the company librarian is the one to see. If not, the local public librarian can be of assistance.

It should be kept in mind that a few well-chosen

Circle 9-3 on Page 19 for extra copy.

publications can give more right-to-the-point information than can many which are merely skimmed. Regular reading should be confined to about six publications each month. Of these six, for example, four might be directly concerned with the reader's immediate technical fields of interest, one a general engineering or scientific journal, and the other an industry news periodical.

Supplementary Reading Plan

Even though the selected periodicals are conscientiously read, much information of value might easily be missed because of its publication in other information sources. This broad area of supplemental information can be screened by abstracts and indexes.

Abstracting and indexing services are available from various private and government sources. The accompanying table lists the more prominent of these, directed toward the needs of the design engineer. In general, an abstract is a summary or abridgment of a publication or article, and will include a concise bibliographical reference to the original. Abstracts can be of two types, informative or indicative, the informative being more comprehensive in scope.

An index, on the other hand, lists only the names or subjects occurring in a document or group of documents, with an indication of the places in which

Abstracts and Indexes:

The following are the more prominent abtract and indexing services useful in design engineering. Abstracts and Indexes pertaining to other specialized areas are also available. These vary in many particulars and it is advisable to consult a library specialist concerning them.

Engineering Index: Engineering Index Inc., 29 W. 29th St., New York 18, N. Y.

An all-around abstracting periodical index. This service, which was originally established in 1884, abstracts some 1400 periodicals, reports, professional society proceedings, and other sources of technical information, and distributes cards containing these abstracts to subscribers on a weekly basis. Abstracts are divided into approximately 250 specialized subject classifications, and the subscriber may purchase one or all of such classifications at prices ranging from $12 to $45 for each. All abstract cards are cumulated in an annual volume which is cross-indexed by subject, has an author index, and is sold independently of the abstract cards. Complete articles abstracted by the service may be obtained from the publisher for a fee, as may translations of foreign-language articles.

Technical Translations: Office of Technical Services, Washington 25, D. C.

Technical Translations is a government publication published twice each month. It contains abstracts of translations of technical material available from the Office of Technical Services, the Library of Congress, Special Libraries Association, co-operating foreign governments, commercial translators and publishers, universities, and other sources.

Translations from nongovernment sources, both foreign and domestic, are collected by the Special Libraries Association Translation Center, and the Office of Technical Services collects those from both domestic and foreign government sources. The latter agency also provides reference service for the location and identification of translated materials, both completed translations and translations in process.

Nuclear Science Abstracts: Superintendent of of Documents, U. S. Government Printing Office, Washington 25, D. C.

Nuclear Science Abstracts is published by the United States Atomic Energy Commission. These, issued semimonthly, in paper-covered book form, include abstracts of literature on nuclear science and engineering as well as immediate and detailed indexes to that literature. It covers 1. Research reports of the United States Atomic Energy Commission and its contractors, 2. Research reports of government agencies, universities, and industrial research organizations on a world-wide basis, 3. Translations, patents, books, and articles appearing in technical and scientific journals. Abstracts are arranged according to broad subject categories. Each abstract is numbered, and the page number on which it appears is given. Collections of United States Atomic Energy Commission reports are maintained in certain large city and university libraries, including the Library of Congress, Washington, D. C. Atomic energy reports of other countries, when abstracted by Nuclear Science Abstracts, are also available through these libraries.

Chemical Abstracts, American Chemical Society, 2 East 64th St., New York 21, N. Y.

Chemical Abstracts is published by the American Chemical Society. While primarily concerned with chemistry, it also covers physics, engineering, and other sciences which are closely related to chemistry. It appears twice each month, is world-wide in scope, and covers books, pamphlets, periodicals, patents, and serials from virtually all countries. Annual indexes by author, patent number, subject, and chemical composition are published. Chemical

they occur. In the sense that it attempts to evaluate the contents, scope or importance of a given publication, an Annotated Index approaches an abstract. A Bibliographical Index is confined to furnishing verification and tracing data.

Some company operated technical libraries publish abstract bulletins, which are segregated by subject. One such bulletin, *Current Engineering Literature*, is published by the General Motors Research Laboratories Library of Warren, Mich. This weekly announcement service is published for in-company use, to pinpoint newly available technical literature. The references are selected from the index card service of *Engineering Index*. Foreign and domestic technical periodicals are covered, including some not in the library's collection, but obtainable by the library from outside sources when required. Most issues include short abstracts of new technical books, preprints of the proceedings of leading technical societies, a listing of university publications concerning investigations in basic science, translations of significant foreign language articles, and research and development reports.

Other company libraries put out similar abstract bulletins and these are generally considered to be extremely effective. Companies publishing these bulletins include the Armstrong Cork Co., Sun Oil Co., and Eli Lilly.

Guides for Supplementary Reading

Abstracts is slanted towards those who have more than a superficial knowledge of chemistry, but is of use to those who are nonspecialists in the chemistry field.

Applied Science and Technology Index, and Business Periodicals Index: H. W. Wilson Co., 950 University Ave., New York 52, N. Y.
An outgrowth of Industrial Arts Index, discontinued in 1957, the Applied Science and Technology Index and Business Periodicals Index are subject indexes to magazines in business and scientific fields. Published monthly and cumulated frequently, each index reports on approximately 120 English-language periodicals, but does not abstract the articles reported. However, for quick leads to articles, these publications should be examined regularly.

Aerospace Engineering Index: Institute of Aerospace Sciences, 2 E. 64th St., New York 21, N. Y. Annual.

Air University Periodical Index: Air University Book Dept., Maxwell Air Force Base, Ala.

Applied Mechanics Reviews: American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y. Monthly.

ASM Review of Metal Literature: American Society for Metals, Metals Park, Novelty, Ohio.

Automation Express: International Physical Index Inc., 1909 Park Ave., New York 35, N. Y. Russian articles translated, abstracted.

Electronics Express: International Physical Index Inc., 1909 Park Ave., New York 35, N. Y. Russian articles translated, abstracted.

Industrial Arts Index: H. W. Wilson Co., 950 University Ave., New York 52, N. Y.

International Aerospace Abstracts: Institute of Aerospace Sciences, 2 E. 64th St., New York 21, N. Y. Monthly.

Official Gazette: Superintendent of Documents, Government Printing Office., Washington 25, D. C. Weekly.

Pacific Aeronautical Library: The Library, Los Angeles, Calif. Card index service.

Physics Express: International Physical Index Inc., 1909 Park Ave., New York 35, N. Y. Russian articles translated, abstracted.

Public Affairs Information Service: Public Affairs Press, 11 W. 40th St., New York 18, N. Y. Bulletin, weekly. Cites selected pamphlets, government publications, books, annuals, periodical articles.

Publications Announcements, No. 1, National Aeronautics and Space Administration, 1520 H. Street N.W., Washington 25, D. C. Semi-monthly. Includes research reports from NASA, British Government sources, and AGARD.

Rand Index of Publications: Rand Corporation, Santa Monica, Calif. Annual. Research report abstracts available from deposit libraries throughout the United States and certain foreign countries.

Research Abstracts and Reclassifications Notice No. 1-130. National Aeronautics and Space Administration, 1520 H Street N.W., Washington, D. C. Irregular.

Resins — Rubbers — Plastics: Interscience Publishers Inc., 250 Fifth Ave., New York 1, N. Y. A literature and patent service.

Technical Abstract Bulletin: Armed Services Technical Information Agency, Arlington 12, Va. Available to government contractors only.

Technical Book Review Index: Special Libraries Assn., 31 East 10th St., New York 3, N. Y. Monthly except July and August. Abstracts new technical books.

The New York Times Index: New York Times Co., 229 W. 43rd St., New York 18, N. Y.

Ulrich's Periodicals Directory: R. R. Bowker Co., 62 W. 45th St., New York 36, N. Y. A classified guide to a selected list of current periodicals, foreign and domestic. Includes indication of where each periodical is indexed.

U. S. Government Research Reports: Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. A monthly listing of government reports available to industry.

U. S. Government Publications Monthly Catalog: Government Printing Office, Washington 25, D. C. Monthly.

A design guide:

Preventing Fatigue Failures

Part 1 — Basic Factors

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Although fatigue failures have been investigated for more than 100 years, the basic mechanism of fatigue is still unknown. However, many methods have been formulated for the prevention of fatigue failures during expected service life of a part.

This series of articles discusses factors that affect fatigue strength. More important, it outlines methods which are helpful in the design of machine components and structural elements that must resist fatigue loading.

This first article discusses the factors which, in general, influence design for the greatest possible fatigue life. Subsequent articles will discuss geometric stress concentrations, effect of metallurgical and mechanical treatments on fatigue life, calculations for determining fatigue life, and effect of biaxial stresses on fatigue life.

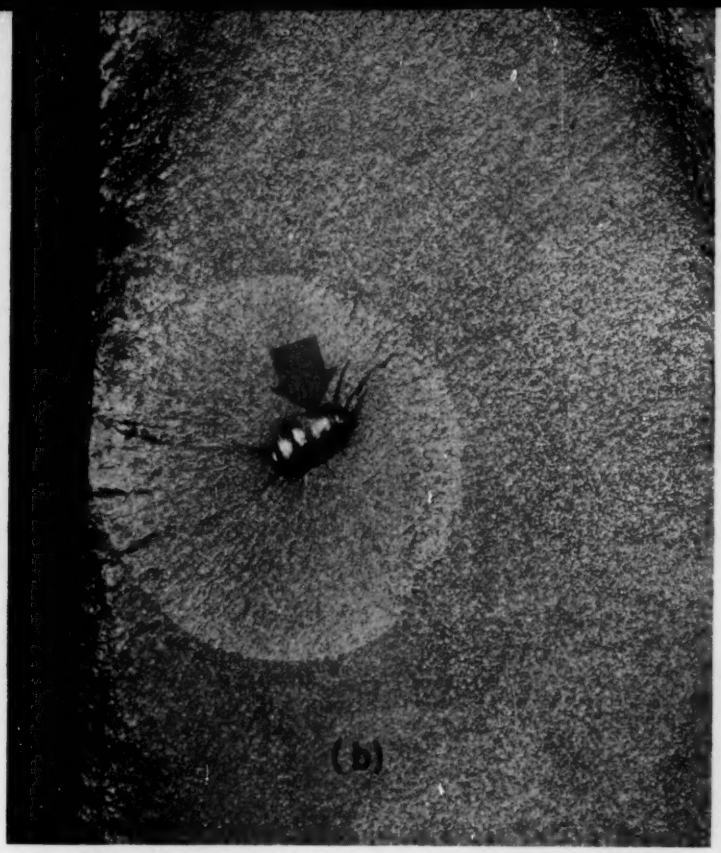

Fig. 1—Fatigue fractures in structural components caused by, *a*, galling at the point indicated by the arrow and, *b*, blowhole in the material.

MOST fatigue failures can be traced to deficiencies in design rather than inadequacies in material or improper manufacture or maintenance. These failures are usually caused by relatively high stress concentrations that might have been eliminated or minimized in the original design with relatively little effort and expense. Fatigue damage in materials is caused by imposed vibratory stresses or by variations in imposed stresses. The damage may range from a submicroscopic, microscopic, or macroscopic crack to a complete fracture.

Fatigue failure usually means the complete fracture of a structure or machine part caused by alternating loads, Fig. 1. However, a fatigue failure may also be defined as the inception of a fatigue crack—particularly if complete fracture of the part will eventually occur.

Generally, fatigue data obtained from laboratory tests of small specimens or assemblies are based on complete fractures of the specimens. These data are of considerable value to the designer, who is often interested in the period between the inception of a fatigue crack and the final fracture.

Failure (fracture) strength depends upon many factors. If the loads are static, the failure strength is closely tied to the ultimate tensile strength, or ultimate yield strength. But if loads are cyclic, the failure strength may range from the full ultimate static strength to a small percentage of the ultimate, depending on life requirements and environment. For example, it is not enough to simply assume that the fatigue strength of a given material is 100,000 psi for 10,000,000 cycles. Such values are usually based on small, highly polished laboratory specimens. Conditions might be such that the allowable fatigue stresses should be not over 15,000 psi for 10,000,000 cycles of loading. Of course, if the part is to be designed for only 10,000 cycles the stresses might be allowed to go as high as 35,000 psi. Fatigue stresses in the given material for other conditions of use might be twice as high. Obviously, any tabulation of allowable fatigue stresses would have to contain many different values for any single material, and include environmental conditions.

No such tabulations are available. However, a great deal of fatigue testing has been done and reported in books and technical papers.[1,2,3] These include both test data and the specific conditions un-

[1]References are tabulated at end of article.

der which they were obtained.* The designer should start with such data and modify the values in accordance with the conditions for which he is designing. In any case, such test data should be used with great caution.

*Comprehensive bibliographies have been published annually, since 1950, by ASTM. They are titled "References on Fatigue."

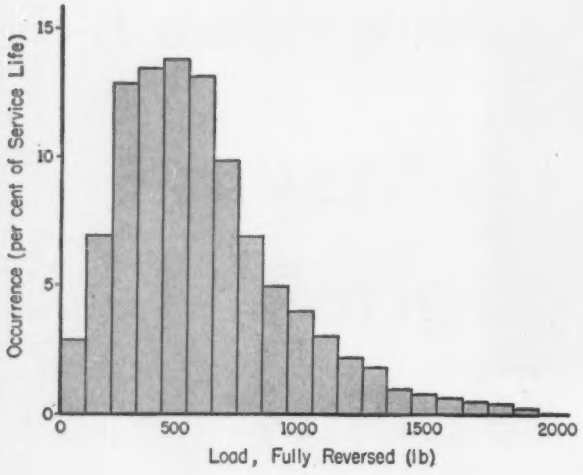

Fig. 2—Histogram of expected fatigue loads on a structural part. The ordinates represent the number of cycles expected for each load interval.

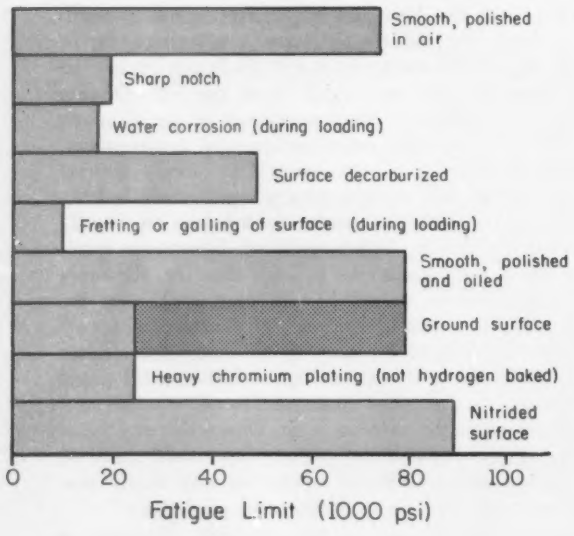

Fig. 3—Approximate fatigue limits of SAE 4340 steel hardened to Rc 31 for various surface conditions. The shaded portion of the graph indicates fatigue limits for the normal range of ground finishes.

Three major factors must be considered in designing a machine or component to withstand fatigue loads:

1. Service loads
2. Critical stresses
3. Material behavior

Service Loads

The many factors involved in analyzing service loads require careful evaluation by the design engineer. These factors can best be represented by a cycle-load histogram of the machine, which should represent all conditions, environments, and malfunctions expected during service life. A typical histogram is shown in Fig. 2.

Various loads and the corresponding vibration cycles for each critical component of the machine or structure during the expected life of the component should be determined as completely and realistically as possible. This should include loads induced by improper operation and by malfunction, since service life may be limited by the number and magnitude of loads occurring during infrequent overloads or improper operation. For example, the life histogram of rotating machines (reciprocating engines, steam turbines, turbojets, etc.) should include resonant loads or stresses that may occur while the machine is brought up to operating speed.

For some types of equipment, load measurements may have been made on similar pieces of equipment during typical service operation. In this case, it is possible to extrapolate (cautiously) this information for a new design. More often, however, load histograms are not available to the designer and he must estimate a histogram on the basis of past experience and available test data.

One point which should not be overlooked in constructing a histogram is that in many cases so-called static loads are actually pulsating loads. For example, the centrifugal stresses of rotating parts in machinery running at constant speed are in reality pulsating stresses, since they return to zero every time the parts become stationary.

The histogram shown in Fig. 2 indicates that the structural part must resist fatigue loads of 100 pounds during 3 per cent of its cycle life, 200 pounds for 7 per cent of its life, 300 pounds for 13 per cent of its life, etc., up to 1900 pounds for about 0.2 per cent of its life. Addition of the load frequencies of loads up to and including 1000 pounds indicates that for about 90 per cent of the cycle life of the part, the service load will not exceed 1000 pounds.

Actual stresses are likely to vary over a wide range during the cycle life of a part. This poses one of the most difficult questions in fatigue design—whether or not fatigue damage will accumulate slowly enough for the part to survive the desired number of fatigue-loading cycles.

Critical Stresses

After a histogram has been constructed, a preliminary design can be made. From this design,

critical fatigue stresses may be computed.

The following factors should be taken into account when computing critical stresses:

1. All stress concentrations that may exist at the points in question. Stress concentrations introduced by improper handling or by service environments (such as stone ingestion in turbojet engines) should be recognized, as well as those resulting from the design itself.

2. The state of stress; that is, whether stress is alternating or pulsating, or whether it is an alternating stress superimposed on a steady stress. Also, the principal stresses and their phases must be calculated.

3. The effect of stresses introduced inadvertently in the assembly. For example, transportation of parts by rail or truck involves considerable jolting, which causes fatigue stressing.

4. The effect of manufacturing tolerances on stresses.

A stress histogram based on these points should be compared with the fatigue strength of the material to be used for the part.

Material Behavior

To determine if a material will fail under calculated stresses, it is necessary to have knowledge of the behavior of the material under all environmental conditions that might affect fatigue-inducing stresses. This should include the effects of manufacturing processes. Fatigue data—including *S-N* curves

Conditions Which Reduce Fatigue Strength

Cause	Remarks
Stress concentrations due to improper design (small fillet radii in shafts, changes in sections, etc.)	Reduction in fatigue strength depends on the geometric factor and the sensitivity of the material to notches. Reduction can be as high as 75 per cent.
Stress concentrations due to improper manufacturing (file marks, rough machined surfaces, etc.)	Difficult to evaluate, since geometry of the notches is usually nonstandard.
Residual tensile surface stresses caused by grinding	Improper grinding may introduce very high tensile stresses, causing loss of fatigue strength up to 10 or 15 per cent.
Residual tensile stresses due to cold forming	Although beneficial compressive stresses can be introduced by cold forming, tensile stresses are sometimes produced, causing a loss of fatigue strength.
Fretting or galling of surfaces that are simultaneously subjected to fatigue stresses	Fretting or galling can result in a fatigue-strength loss of up to 80 per cent. All clamped or riveted joints are subject to this condition.
Corrosion	Corrosion caused by moisture or liquids can reduce fatigue strength by as much as 75 per cent. Most metals require an adequate surface protection.
Plating	Plating usually reduces the fatigue strength of a part, the amount depending on the type of plating, the thickness of the plate, the method of plating, and the embrittlement-relief treatment. Chromium plating in some instances can cause a large loss in fatigue strength.
Surface conditions introduced by heat treatment (oxide penetration, decarburization, etc.)	Only by the most careful control can the surface be protected during the heat-treating process.
Size	Most published fatigue data on materials are based on small laboratory specimens which do not adequately evaluate the fatigue strength of large parts. Large parts may be weaker than small test specimens by more than 10 per cent.
Speed	Although operating speeds ordinarily have only a minor effect on fatigue life, very high or very low speeds usually reduce fatigue strength.
Shape	It has been found that the shape of a part has some influence on its fatigue strength. Rectangular specimens may be up to 30 per cent weaker than round ones.
Inclusions in materials	Nonmetallic inclusions in high strength steels may reduce fatigue strength to a point considerably below that of relatively inclusion-free steels.
Assembly stresses	Tensile stresses induced by assembly have an adverse effect on fatigue strength.

—published on a material are not sufficient, since such information is usually based on laboratory tests of small, carefully polished specimens.

Seldom, if ever, are the fatigue strengths observed in the laboratory realized in full-scale components subjected to service environments. Numerous factors can reduce the "par" fatigue strength obtained from laboratory specimens, but there are relatively few methods of preventing or compensating for environmental effects. Also, a detailed knowledge of manufacturing processes and service environment is necessary before the structural adequacy of the component can be judged.

The magnitudes of reductions caused by some

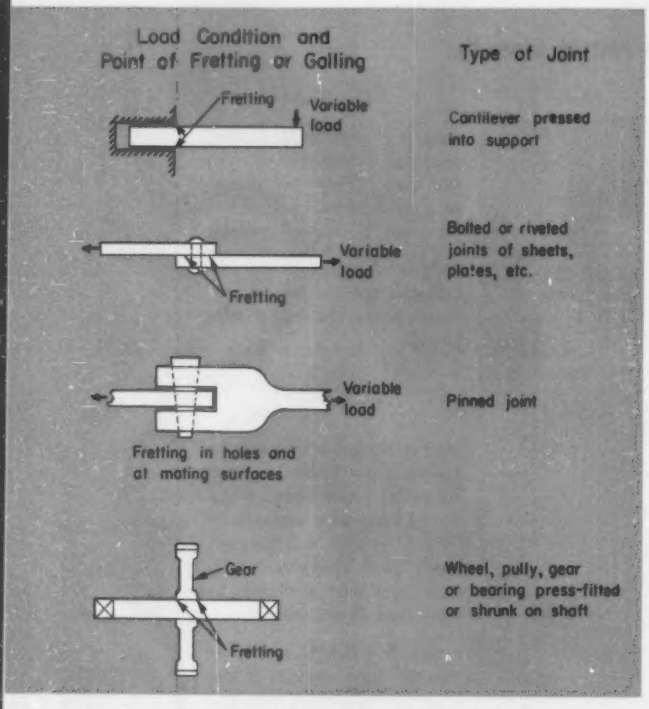

Fig. 4—Various types of joints which are subject to fretting or galling.

factors on a given steel are shown in Fig. 3. One factor that, although responsible for a large reduction in fatigue strength, has been overlooked by many designers in the past is fretting or galling at bolted, riveted, pinned, or press-fit joints subjected to alternating loads. Effective stress concentrations of 4:1 to 5:1 have been observed. Making the joint tighter might be expected to improve its strength. However, this only localizes fretting at the edge of the clamped joint and has little benefit on total strength. Some types of joints which are subject to this reduction are illustrated in Fig. 4.

Fretting or galling are only two of many conditions that help to reduce the "par" value of a material. Since so many factors can reduce the fatigue strength of a material, the strength of a finished part or machine is usually only a relatively small fraction of the "par" value, unless elaborate precautions are taken in every critical region of the part. In addition, there are so many factors involved in the final strength of most parts, each of which contributes to variation in strength, that there is an inherent scatter or variation in the strength of the final part, regardless of the quality of the material.

Because the estimation of actual fatigue strength of a structure is subject to a wide variety of errors it is necessary, in most cases, to fatigue-test the entire structure—or its major components—for an accurate assessment of its fatigue strength. The testing of full-scale structures, components, or assemblies is usually very costly, since the cost of the assembly is often high, the speed of testing low, and the availability of parts limited. Nevertheless, many engineers believe (and perhaps rightfully so) that this is the only real test. Some engineers even express the extreme opinion that laboratory tests of small specimens have little value. This latter view is incorrect, since the strength of the finished structure or machine is based on the material itself.

Basic Fatigue Strength of Materials

Analyses of fatigue failures that have occurred in service have proved that most failures are caused by factors unrelated to the inherent fatigue strength of the materials. However, this does not mean that the basic fatigue strength of a material is not important. It is the starting point of all structural design.

All materials, even when fatigue tested under ideal conditions, where the variations of all outside influences have been minimized or eliminated show surprisingly large amounts of variation in fatigue life at a constant stress. The amount of variation in basic fatigue characteristics is a direct measure of the quality of the material. This characteristic is one of the basic mechanical properties of materials, although in the past it has often been overlooked. Recent investigations have been undertaken to determine the causes of variation in fatigue characteristics.

This property of materials causes difficulty when tests are conducted to compare materials and processes, or to obtain accurate values of fatigue strength or life. Variations in basic fatigue strength have obscured many important trends in materials or processes.

Part 2 of this series will cover geometric stress concentrations.

REFERENCES

1. "Air Weapons Materials Application Handbook—Metals and Alloys," *Air Research and Development Command Technical Report* 59-66.
2. H. N. Cummings—"Some Quantitative Aspects of Fatigue of Materials," *Wright Air Development Division Technical Report* 60-42.
3. H. J. Grover, S. A. Gordon, and L. R. Jackson—"Fatigue of Metals and Structures," Bureau of Aeronautics, Dept. of the Navy, 1954.

A simplified procedure for solving

Natural Frequencies of Multiple-Mass Systems

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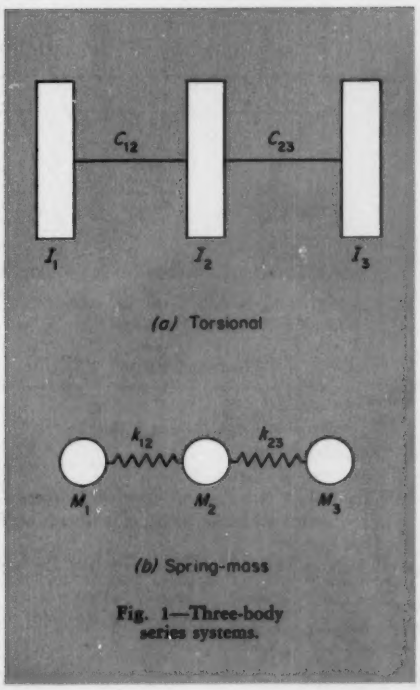

Fig. 1—Three-body series systems.

MECHANICAL assemblies can often be considered as systems of lumped masses and interconnected stiffnesses. As the number of masses increases, calculation of system vibration characteristics becomes increasingly complex. The method presented in this article for computing natural frequencies of such systems can reduce calculation time by as much as two thirds as compared with the usual method of solution by an equation of high order. This procedure has the further advantage of giving a direct solution for torsional frequencies of complex interconnected systems such as those involved in antibacklash gearing arrangements with redundant shafts.

Simple Systems

Typical three-body series systems may either be of the torsional type, Fig. 1*a*, or of the spring-mass type, Fig. 1*b*. These systems are equivalent, moment of inertia I and torsional stiffness C being interchangeable, respectively, with mass M and spring constant k. Fig. 2 illustrates a more complex system of four bodies in a series-parallel arrangement, the first two bodies being connected in series, the

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last two in parallel. Again the equivalence of the torsional and spring-mass systems are evident.

The equation for solution of the simple three-body system of Fig. 1*a* is (see Nomenclature)

$$y = 1 + \frac{a_1}{\omega^2 - p_1} + \frac{a_2}{\omega^2 - p_2} + \frac{a_3}{\omega^2 - p_3} = 0 \qquad (1)$$

where

$$a_1 = \frac{-C_{12}^2}{I_1 I_2 (p_1 - p_2)}$$

$$a_2 = \frac{C_{12}^2}{I_1 I_2 (p_1 - p_2)} + \frac{C_{23}^2}{I_2 I_3 (p_3 - p_2)}$$

$$a_3 = \frac{-C_{23}^2}{I_1 I_3 (p_3 - p_2)}$$

and $p_1 = C_{12}/I_1$; $p_2 = (C_{12} + C_{23})/I_2$; $p_3 = C_{23}/I_3$.

Because the values of a and p are expressed in terms of the physical constants of the system components, two relations may be used to check their accuracy:

$$a_1 + a_2 + a_3 = 0 \qquad (2)$$

and

$$\frac{a_1}{p_1} + \frac{a_2}{p_2} + \frac{a_3}{p_3} = 1 \qquad (3)$$

Also, the roots of the frequency equation ω_1^2 and ω_2^2, satisfy the relationship.

$$\omega_1^2 + \omega_2^2 = p_1 + p_2 + p_3 \qquad (4)$$

which provides a check on the final calculation of the frequencies.

The plotted form of Equation 1, where $p_1 < p_2 < p_3$, is shown in Fig. 3. The curve passes through 0 (the zero root), has asymptote $y = 1$, and asymptotes $\omega^2 = p_1$, $\omega^2 = p_2$, and $\omega^2 = p_3$.

The curve of Fig. 3 is for $a_1 > 0$, $a_2 < 0$, and $a_3 < 0$. The change in sign between a_1 and a_2 gives a loop which does not cross the ω^2 axis. Thus, in this case, the two roots other than zero are between p_2 and p_3 and above p_3. These roots may be calculated by any method of successive approximation (including trial and error) since the curve cuts the ω^2 axis at a steep angle.

Of course, in this simple case, the roots may be calculated directly by solving a quadratic equation. The method is presented here only to introduce and illustrate the general method for more complex systems. Equation 1 is particularly suitable for desk-calculator computations.

General Solution

The frequency equation for the general condition of n bodies is

$$y = 1 + \frac{a_1}{\omega^2 - p_1} + \frac{a_2}{\omega^2 - p_2} + \frac{a_3}{\omega^2 - p_3} + \ldots + \frac{a_n}{\omega^2 - p_n} = 0 \qquad (5)$$

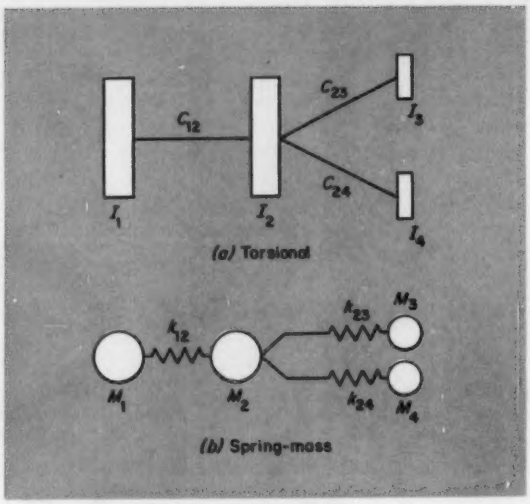


Fig. 2—Four-body series-parallel systems.

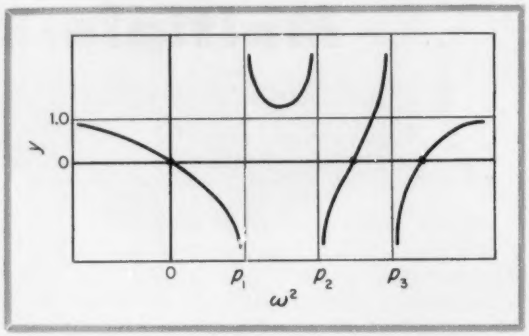


Fig. 3—Graphic form of simple three-body series system solution (Equation 1).

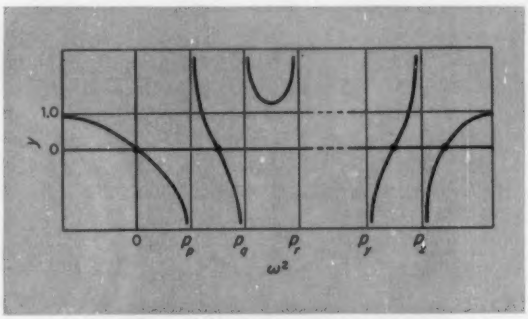


Fig. 4—Graphic form of n-body general solution (Equation 5).

Nomenclature

a = Constant
C = Torsional stiffness, lb-in. per rad
f = Frequency, cps
I = Moment of inertia, in.^{4}
p = Equivalent angular or circular frequency of one body with all other bodies of a system rigidly held, rad per sec
ω = Angular or circular frequency, rad per sec

Subscripts

pq = Between pth and qth body
r = For rth body

Table 1—Determinants for Constant a

General Form—for n bodies:

$$\begin{vmatrix} I_1 & \frac{C_{12}}{\omega^2 - p_1} & \frac{C_{13}}{\omega^2 - p_1} & \frac{C_{14}}{\omega^2 - p_1} & \cdots & \frac{C_{1n}}{\omega^2 - p_1} \\ \frac{C_{12}}{\omega^2 - p_2} & I_2 & \frac{C_{23}}{\omega^2 - p_2} & \frac{C_{24}}{\omega^2 - p_2} & \cdots & \\ \frac{C_{13}}{\omega^2 - p_3} & \frac{C_{23}}{\omega^2 - p_3} & I_3 & \frac{C_{34}}{\omega^2 - p_3} & \cdots & \\ \vdots & \vdots & \vdots & \vdots & & \\ \frac{C_{1n}}{\omega^2 - p_n} & & & & & I_n \end{vmatrix} \times \frac{1}{I_1 I_2 I_3 \ldots I_n}$$

Specific Form—to solve for a_1:

$$\begin{vmatrix} 0 & C_{12} & C_{13} & C_{14} & \cdots & C_{1n} \\ \frac{C_{12}}{p_1 - p_2} & I_2 & \frac{C_{23}}{p_1 - p_2} & \frac{C_{24}}{p_1 - p_2} & \cdots & \\ \frac{C_{13}}{p_1 - p_3} & \frac{C_{23}}{p_1 - p_3} & I_3 & \frac{C_{34}}{p_1 - p_3} & \cdots & \\ \vdots & \vdots & \vdots & \vdots & & \\ \frac{C_{1n}}{p_1 - p_n} & & & & & I_n \end{vmatrix} \times \frac{1}{I_1 I_2 I_3 \ldots I_n}$$

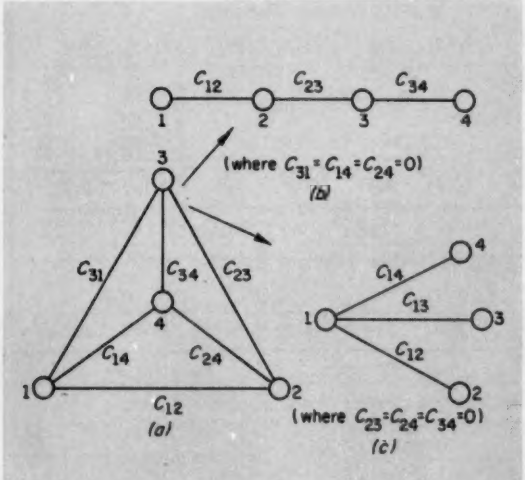


Fig. 5—Four-body system. Fully interconnected system, *a*, can be treated as a series system, *b*, or as a parallel system, *c*, when appropriate stiffnesses are made equal to zero.

where

$$p_1 = \frac{C_{12} + C_{13} + C_{14} + \ldots C_{1n}}{I_1}$$

The numerator represents the sum of torsional-stiffness values of all members physically connected to the first body. The same general form is used for p_2, $p_3 \ldots p_n$. Thus, the frequency of the rth body (if all other bodies were rigidly held) would be $(p_r)^{1/2}/(2\pi)$, and C_{pq} would be the torsional-stiffness of the member connecting the bodies whose moments of inertia are I_p and I_q.

One root of Equation 5 is $\omega^2 = 0$. The following checks can be made after calculating the values of a, p, and the roots:

$$a_1 + a_2 + a_3 + \ldots + a_n = 0 \qquad (2a)$$

$$\frac{a_1}{p_1} + \frac{a_2}{p_2} + \frac{a_3}{p_3} + \ldots + \frac{a_n}{p_n} = 1 \qquad (3a)$$

$$\text{sum of roots in } \omega^2 = p_1 + p_2 + p_3 + \ldots + p_n \qquad (4a)$$

Values of a are calculated from the general-form determinant of Table 1. To obtain a specific a, say a_r:

1. Replace $(\omega^2 - p_r)$ by 1.
2. Replace $(\omega^2 - p_p)$ by $(p_r - p_p)$ where $r \neq p$.

3. Replace I_r by 0.

Thus, for example, to calculate a_1, the determinant is modified to the second form shown in Table 1.

In the curves showing the general solution, Fig. 4, the p's are arranged in order ($p_p < p_q < p_r < \ldots p_y < p_z$) and there is a change of sign in the a's between a_q and a_r giving a loop which does not intersect the axis.

Variations

A fully interconnected four-body system, Fig. 5*a*, can be represented as either a simple series system, Fig. 5*b*, or a parallel system, Fig. 5c, by making appropriate stiffnesses equal to zero.

For example, Fig. 6 shows a seven-body problem whose solution covers a large number of practical cases. As in the case of the four-body system of Fig. 5, the seven-body system can be reduced to simpler systems by putting appropriate masses or stiffnesses equal to zero.

Table 2 evaluates fully the values of a for the seven-body system (or any simpler system derived from it) and eliminates the need of writing down and expanding the appropriate determinant. Values of p for use with Table 2 are:

$$p_1 = \frac{C_{12}}{I_1} \qquad p_2 = \frac{C_{12} + C_{23}}{I_2}$$

$$p_3 = \frac{C_{23} + C_{37} + C_{36} + C_{35} + C_{34}}{I_3}$$

$$p_4 = \frac{C_{34}}{I_4} \qquad p_5 = \frac{C_{35}}{I_5}$$

$$p_6 = \frac{C_{36}}{I_6} \qquad p_7 = \frac{C_{37}}{I_7}$$

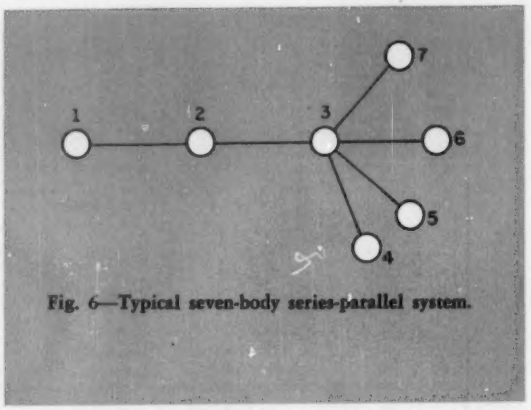


Fig. 6—Typical seven-body series-parallel system.

Table 2—Values of a for a Seven-Body Series-Parallel System

$$a_1 = -\frac{C_{12}^2}{I_1 I_2 (p_1 - p_2)} + \frac{C_{12}^2}{(p_1 - p_3)(p_1 - p_2)} \times \frac{1}{I_1 I_2 I_3} \left[\frac{C_{34}^2}{I_4 (p_1 - p_4)} + \frac{C_{35}^2}{I_5 (p_1 - p_5)} + \frac{C_{36}^2}{I_6 (p_1 - p_6)} + \frac{C_{37}^2}{I_7 (p_1 - p_7)} \right]$$

$$a_2 = -\frac{C_{12}^2}{I_1 I_2 (p_2 - p_1)} - \frac{C_{23}^2}{I_2 I_3 (p_2 - p_3)} + \frac{C_{12}^2}{(p_2 - p_1)(p_2 - p_3)} \times \frac{1}{I_1 I_2 I_3} \left[\frac{C_{34}^2}{I_4 (p_2 - p_4)} + \frac{C_{35}^2}{I_5 (p_2 - p_5)} + \frac{C_{36}^2}{I_6 (p_2 - p_6)} + \frac{C_{37}^2}{I_7 (p_2 - p_7)} \right]$$

$$a_3 = -\frac{C_{23}^2}{I_2 I_3 (p_3 - p_2)} - \frac{C_{34}^2}{I_3 I_4 (p_3 - p_4)} - \frac{C_{35}^2}{I_3 I_5 (p_3 - p_5)} - \frac{C_{36}^2}{I_3 I_6 (p_3 - p_6)} - \frac{C_{37}^2}{I_3 I_7 (p_3 - p_7)} + \frac{C_{12}^2}{(p_3 - p_1)(p_3 - p_2)} \times \frac{1}{I_1 I_2 I_3} \left[\frac{C_{34}^2}{I_4 (p_3 - p_4)} + \frac{C_{35}^2}{I_5 (p_3 - p_5)} + \frac{C_{36}^2}{I_6 (p_3 - p_6)} + \frac{C_{37}^2}{I_7 (p_3 - p_7)} \right]$$

$$a_4 = -\frac{C_{34}^2}{I_3 I_4 (p_4 - p_3)} + \frac{C_{12}^2 C_{34}^2}{I_1 I_2 I_3 I_4 (p_4 - p_3)(p_4 - p_2)(p_4 - p_1)}$$

$$a_5 = -\frac{C_{35}^2}{I_3 I_5 (p_5 - p_3)} + \frac{C_{12}^2 C_{35}^2}{I_1 I_2 I_3 I_5 (p_5 - p_3)(p_5 - p_2)(p_5 - p_1)}$$

$$a_6 = -\frac{C_{36}^2}{I_3 I_6 (p_6 - p_3)} + \frac{C_{12}^2 C_{36}^2}{I_1 I_2 I_3 I_6 (p_6 - p_3)(p_6 - p_2)(p_6 - p_1)}$$

$$a_7 = -\frac{C_{37}^2}{I_3 I_7 (p_7 - p_3)} + \frac{C_{12}^2 C_{37}^2}{I_1 I_2 I_3 I_7 (p_7 - p_3)(p_7 - p_2)(p_7 - p_1)}$$

Example Problem

Determine the natural frequencies of the five-body system of Fig. A. Values of I and C are shown in their appropriate positions. This arrangement can be derived from the seven-body system (Fig. 6).

Solution

Calculate values of p. From the equations for the seven-body system,

$$p_2 = \frac{0.04 \times 10^6}{10} = 4000$$

$$p_3 = \frac{(0.04 + 0.8 + 0.05 + 2.7)10^6}{115} = 31{,}217.3$$

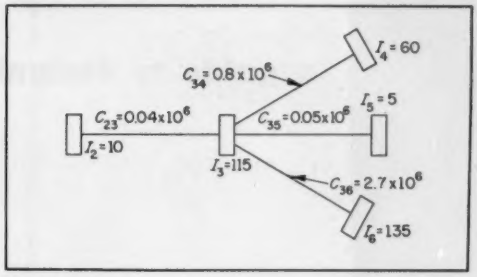


Fig. A

Similarly, $p_4 = 13{,}333$; $p_5 = 10{,}000$; $p_6 = 20{,}000$.

From Table 2, calculate values of a:

$$a_2 = \frac{16 \times 10^8}{10 \times 115 \times 27{,}217.3} = 51.119$$

$$a_4 = \frac{64 \times 10^{10}}{60 \times 115 \times 17{,}884} = 5186.8$$

Similarly, $a_3 = -47{,}305$; $a_5 = 204.92$; $a_6 = 41{,}862$.

Check the sum of the a values (Equation 2a):

$$47{,}304.839 - 47{,}305 \cong 0$$

Check the sum of the a/p values (Equation 3a):

$$2.51537 - 1.51534 \cong 1$$

Substitute the values of a and p in Equation 5:

$$y = 1 + \frac{51.119}{\omega^2 - 4000} + \frac{204.92}{\omega^2 - 10{,}000} + \frac{5186.8}{\omega^2 - 13{,}333} + \frac{41{,}862}{\omega^2 - 20{,}000} - \frac{47{,}305}{\omega^2 - 31{,}217} = 0$$

Sketch the y function, Fig. B. The roots lie, of course, between 4000 and 10,000; 10,000 and 13,333; 13,333 and 20,000; and above 31,217.

Each root may be found by trial and error or by the following method of iteration.

For root ω^2 between 4000 and 10,000, assume $\omega^2 = 4000 + \delta_1$. Substitute this value in the first term involving ω^2, and in the other terms, substitute 4000 for each ω^2. Solve for δ_1.

$$\delta_1 = \frac{51.119}{0.4682} = 109.18$$

Thus, a closer approximation is $\omega^2 = 4109$. The equation is then solved again, with $4000 + \delta_2$ being substituted for the first ω^2 root, and 4109 for the other ω^2 roots. Solution yields $\delta_2 = 105.12$, and $\omega^2 = 4105.12$. If the process were carried one step further, the next result would be $\omega^2 = 4105.25$. The first root, therefore, correct to four places, is 4105.

By the same process, the second root is determined (assume $\omega^2 = 10{,}000 + \delta_1$). The first trial produces $\omega^2 = 10{,}081.827$, the second $\omega^2 = 10{,}081.375$. Thus, the root, correct to five places, is 10,081.

For the third root, the process yields successive δ values of 2021, 1040, 1449, 1266, 1346, 1310, 1326, 1319, and 1322. Thus, correct to four places, the root is $\omega^2 = 14{,}655$.

In the same manner, the fourth root is determined to be 49,707.

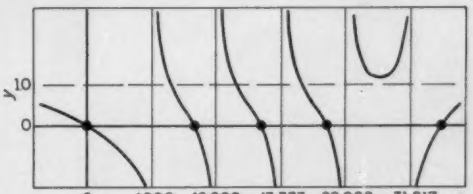


Fig. B

For a final check on the ω^2 values, their sum should equal the sum of the p values (Equation 4a). For the roots determined, $\Sigma\omega^2 = 78{,}548$ and $\Sigma p = 78{,}550$. Hence, the check holds to four figures.

Natural vibration frequencies can now be calculated from the general relationship, $f = \omega/2\pi$. Hence, $f_1 = (4109)^{1/2}/2\pi = 10.2$ cps. Similarly, $f_2 = 15.94$ cps; $f_3 = 19.27$ cps; $f_4 = 35.48$ cps.

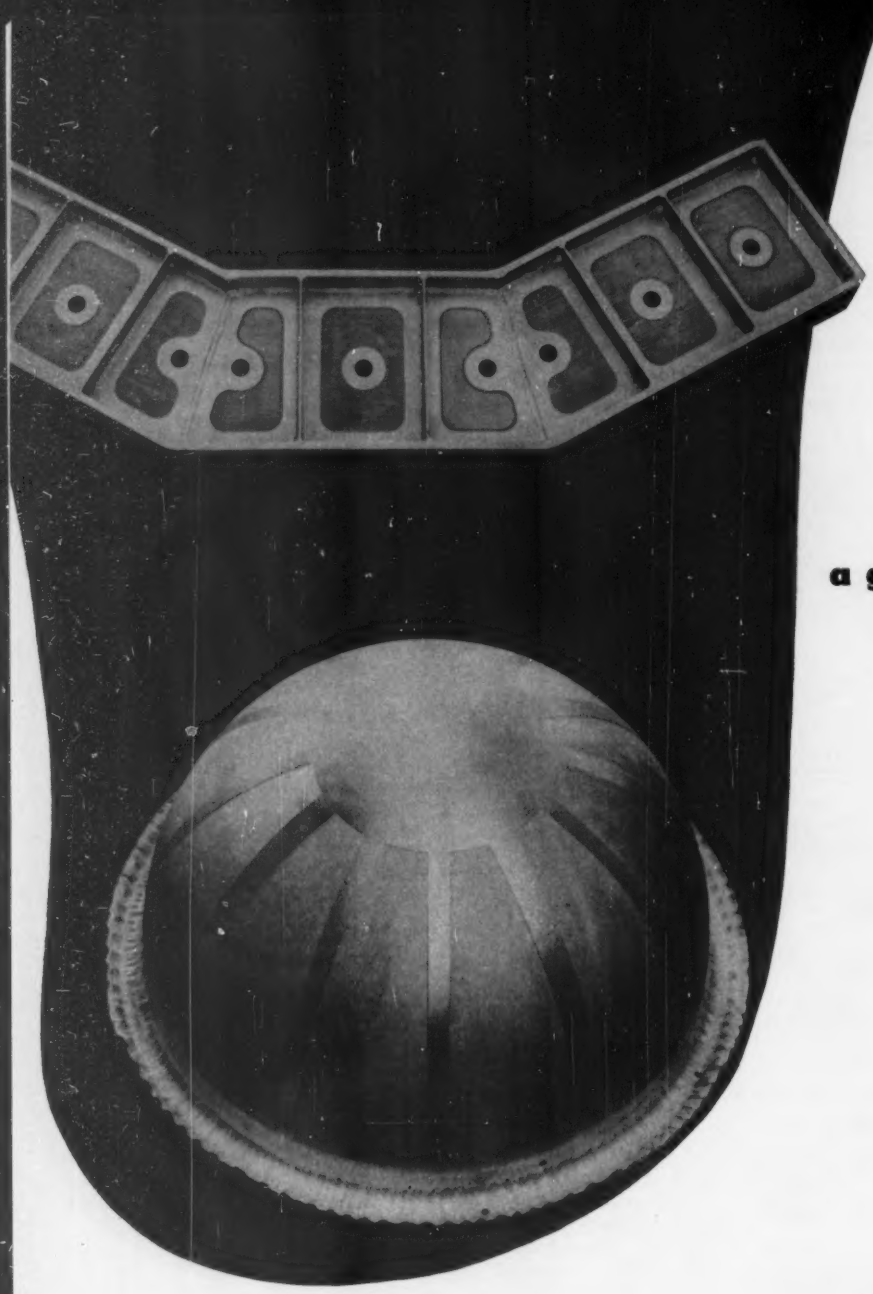
When I_5, I_6, I_7, C_{35}, C_{36}, and C_{37} are set equal to zero, the simple four-body series system is obtained. Other configurations may be obtained from this model in a similar manner.

Method Summary

The following sequence summarizes the method of solution for the natural frequencies of lumped-mass systems:

1. Calculate the p values.
2. Calculate the a values either directly from the seven-body problem, Table 2, or by using the determinant.
3. Check the values of a and p by the relations of Equations 2a and 3a.
4. Sketch the curve for Equation 5 and determine the limits between which the roots lie.
5. Calculate the roots by any suitable method of successive approximation.
6. Check the roots by Equation 4a.
7. The natural frequencies, f, of the system are

$$f_1 = \frac{\omega_1}{2\pi},\ f_2 = \frac{\omega_2}{2\pi},\ \ldots,\ f_n = \frac{\omega_n}{2\pi}$$



a guide to designing

Top—Chemical milling reduces web thicknesses of welded beam to 0.060, 0.040, and 0.020 in. Material is Rene' 41. (Photo courtesy Altamil Corp.)

Bottom—Deep-drawn pressure-tank component for Navajo missile has integral lands and 0.060-in. deep chemically-milled areas. (Photo, courtesy North American Aviation Inc.)

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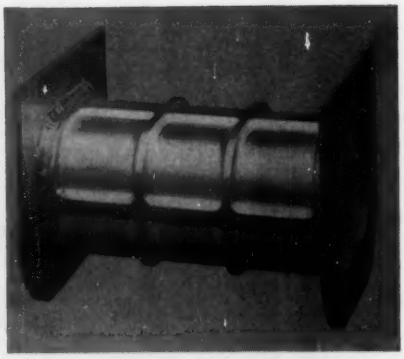


Chemically milled 6061 aluminum tube is designed with 0.312-in. thick walls at the welded areas where strength is needed. Reduced wall sections are 0.040 in. thick. (Photo, courtesy Altamil Corp.)

Chemically Milled Structures

CHEMICAL milling has evolved as a valuable complementary process to the more conventional metal-removal methods of milling and machining. The process removes metal by controlled immersion of parts in an etching solution. Parts can be flat, preformed, or irregular in shape, and metal can be removed from the entire surface or from selected areas only. This article discusses the advantages and limitations of chemical milling and presents up-to-date information for designing chemically milled parts.

Design

The design recommendations that follow are for normal production parts. If tolerances or dimensions are required that exceed these recommendations, prototype parts should be tested to establish specific process procedures.

Depth of Cut: Although cuts up to 2 in. deep have been made in plate stock, the following general limits are used as a design guide for maximum depth: 1. Sheet and plate, 0.500 in. 2. Extrusions, 0.150 in. 3. Forgings, 0.250 in.

Depth Tolerances: The chemical milling process reproduces the thickness variations of the original stock. Thus, when forging or machining operations precede chemical milling, final tolerances must either be enlarged to allow for the thickness variations introduced by these operations, or these variations must

The Chem-Mill Process is patented by North American Aviation Inc. Exclusive rights have been granted to Turco Products Inc. to sublicense other firms.

Process Advantages

- A part may be chemically milled on both sides simultaneously. Thus, warpage which might result from the release of residual stresses is minimized.
- Many parts can be chemically milled at one time.
- Close tolerances can be held.
- Parts may be produced with thin web sections without the danger of excessive warpage or distortion. Proper relationships between pocket size and web thickness must be maintained, however. Generally, web thicknesses can be reduced below practical machining, forging, casting, or forming limits.
- Sheets, extrusions, or formed sections can be tapered on one or both sides.
- Sandwich-type structural parts can be designed with heavy bands or stiffeners (integral with one or both skins) at attach points.
- Parts may be formed and heat-treated prior to the chemical-milling operation. Warpage resulting from heat-treating is thus minimized.
- Chemically milled light-weight integrally stiffened parts often eliminate the need for riveting or welding.
- Chemically milled parts normally require no subsequent sanding or polishing of the milled surface.
- Surface finish of many castings can be improved by chemical milling.
- Thin parts may be blanked out with the use of photosensitive masks and spray-etching equipment.

Process Limitations

- Fillet radii are approximately equal to the depth of cut. Inside corners take a spherical shape; outside corners remain sharp.
- Aluminum castings are often difficult to mill chemically due to the porosity and nonhomogeneity of the cast material.
- Chemical milling over a welded area often results in pits and uneven etching. Many welded materials can be satisfactorily chemically milled; however, individual tests should be performed to determine the advisability of processing a particular part.
- Surface irregularities such as dents and scratches are reproduced in the chemically milled surface of aluminum alloys.
- Surface waviness and thickness variations are reproduced.
- Normally, cuts deeper than 0.500 in. are not recommended.
- Holes, deep and narrow cuts, narrow lands, and sharp, steep tapers are usually impractical by chemical milling.

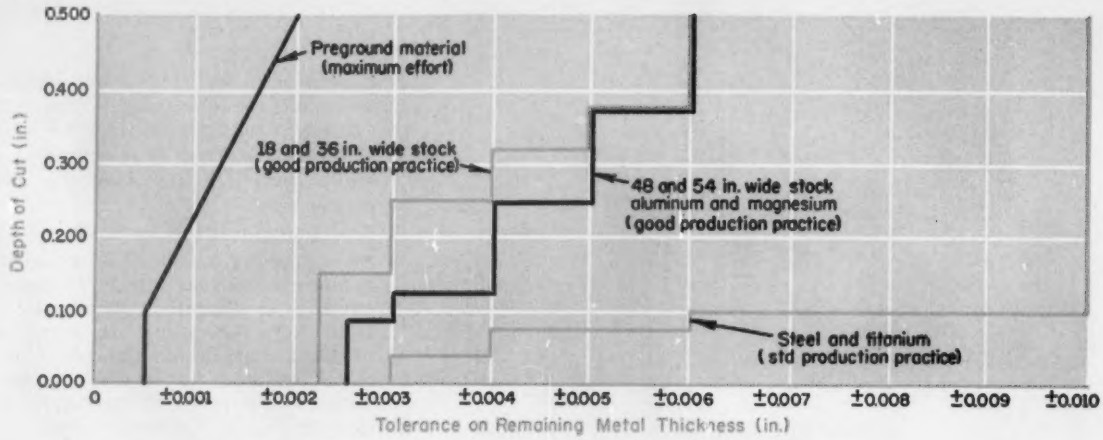


Fig. 1—Thickness tolerance versus depth of cut for chemically milled parts.

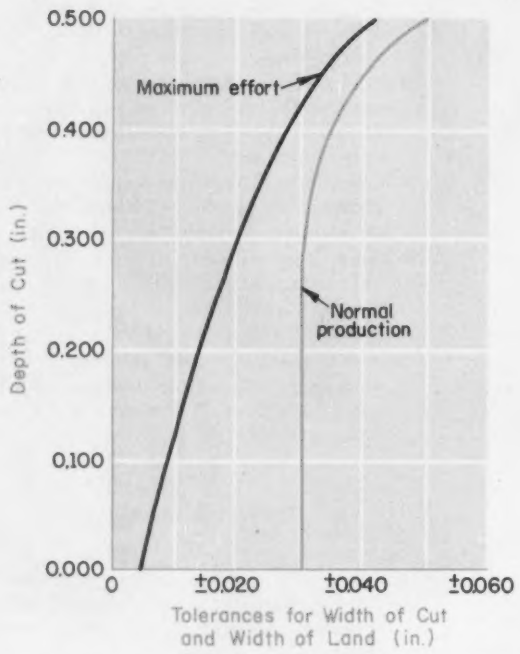


Fig. 2—Recommended minimum land widths and cut widths for normal production and for maximum-effort production.

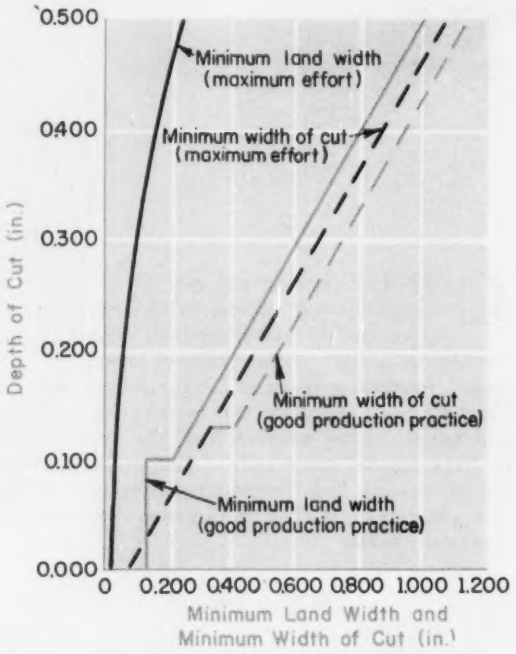


Fig. 3—Tolerances on land widths and cut widths.

be removed. Tolerances can be improved by: 1. Using premium or close-tolerance stock. 2. Pregrinding stock to a close tolerance. 3. Handling of parts individually during the etching cycle. 4. Using the narrower widths of standard sheet stock (which are controlled to a closer tolerance by the producing mill).

A reasonable production tolerance for chemical milling is ±0.002 in., Fig. 1. The stock tolerance prior to milling must, of course, be added.

Width of Cut: The minimum width of cut should be twice the depth of cut plus 0.060 in. for cuts up to 0.125 in. deep and twice the depth plus 0.125 in. for cuts over 0.125 in. deep, Fig. 2.

Land Width: The minimum land width should be twice the depth of cut, but not less than 0.125 in. Narrower lands are possible but are relatively expensive to achieve. Very narrow lands may be made by using silk-screened masks (for shallow cuts only), or by using photosensitive masks. Fig. 2 shows minimum recommended land and cut widths for normal production practice and for maximum effort. Tolerances for land and cut widths are shown in Fig. 3.

Taper: Continuous tapers are accomplished by controlling the rate at which parts are lowered into or withdrawn from the etchant solution. This type of taper, Fig. 4*a*, should not exceed 0.010 in. per ft for steel and 0.100 in. per ft for aluminum.

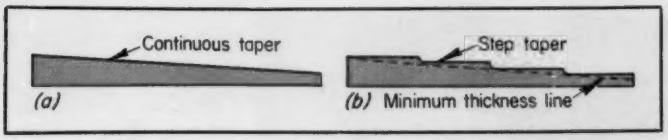
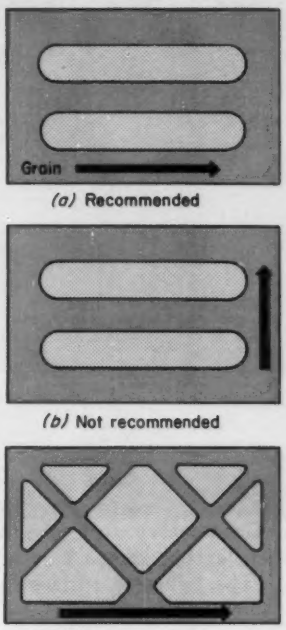


Fig. 4—Continuous taper, *a*, and step taper, *b*, produced by chemical milling.

Step tapers or step cuts, Fig. 4*b*, are approximations of true tapers achieved by a series of immersions in the etchant solution with the mask being progressively stripped between immersions. This type of taper is often less expensive than the equivalent continuous taper, particularly when a part is complex and requires several different tapers. The continuously tapered part, however, is lighter.

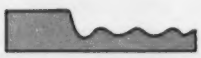
Grain Direction: Grain direction should always be specified for chemically milled aluminum parts. Wherever possible, the longest cut should be made parallel to the grain, Fig. 5*a*. Grid patterns should be laid out at 45 deg to the grain direction, Fig. 5*c*.

Fig. 5—Preferred grain direction for chemically milled cuts in aluminum parts.



Glossary of Chemical-Milling Terms

Channeling: The formation of a groove or channel at the fillet.



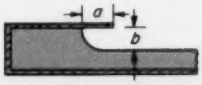
Channeling, Gas: The formation of vertical grooves or channels in the etched surface by bubbles of hydrogen ascending to the surface of the etch bath.

Contouring: To chemically mill.

Cut (or depth of cut): The thickness of metal removed, measured in the direction normal to the original metal surface.

Dishing: Thinning of the central portion of a web resulting from an increasing etch rate from side to center of a cut, due to improper agitation, racking, or temperature control.

Etching: The process of removing metal from desired areas of a part by dissolving it in a solution.



Etch Factor (or undercut ratio): The ratio of the distance etched beneath the mask, *a*, to the depth of cut, *b*.

Etch Rate: The amount of metal removed per unit time (usually expressed in mils per minute).

Fillet: The concave shoulder between the etched and nonetched surfaces.

Fillet Notch (or notching): A notch at the bottom of the fillet radius caused by scribing too deeply.

Gang Milling: The etching of more than one part at a time. Usually, the etching of one sheet which will be cut into two or more parts after chemical milling.

Islands: High spots within an etched area which result from a nonuniform etch rate, usually caused by the unwanted masking action of dirt or particles of mask which remain on the surface to be etched.

Land: A relatively narrow strip of unetched metal dividing adjacent etched areas.

Line Definition: Refers to the quality of an etched line, that is, the extent the actual etched line deviates from the ideal line.

Mask: Any coating, in any form, applied to protect metal parts from the action of an etching solution.

M/S/M: Mils per side per minute (etching rate).

Over mask: The mask which extends over the desired etch line.

Pitting: Formation of pits or depressions in the etched surface.

Ridging: Formation of a raised ridge at the base of the fillet.

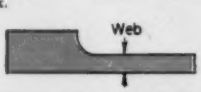
Step Cuts: Multiple cuts of different depths in the same piece of material.

Stripping: Manual removal of unwanted mask on areas which are to be chemically milled.

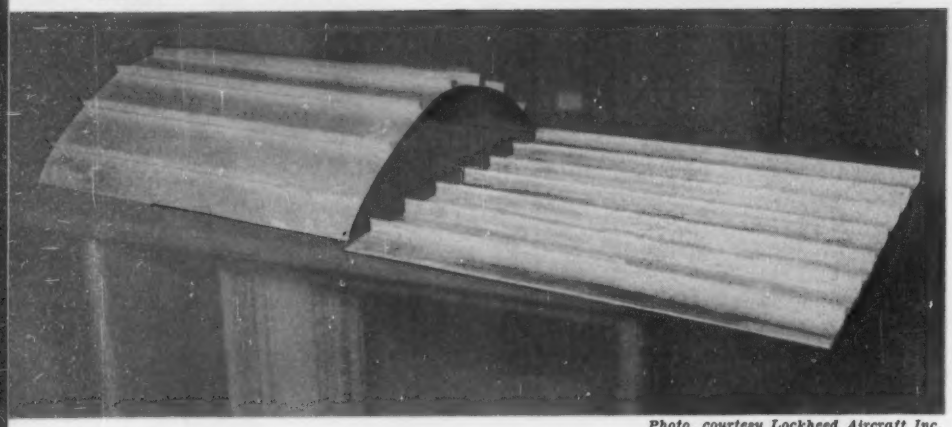
Taper Rate (or immersion rate): The rate at which a part is lowered into (or raised out of) the etchant to taper a part.

Trim: The excess metal surrounding a part which is to be etched. Tool holes and attachment holes are located in the trim area which is later removed.

Undercut: The distance which the etchant cuts or etches underneath the mask.



Web: The thinned metal section remaining after chemical milling.



Integrally stiffened aluminum skins are first extruded as a tube with fins, then cut and chemically milled. Resulting web and fin thicknesses are below extruding limits. This application of milling requires no masking.

Photo, courtesy Lockheed Aircraft Inc.

Surface Finish: The surface finish of chemically milled parts is determined by the initial surface finish, the alloy, the heat-treat condition, and the depth of cut. Good-quality stock, free from scratches, pits, and other damage, should be specified for optimum results. The following surface finishes can be expected:

- **Aluminum:** Surface smoothness varies from 70-160 rms depending on alloy and depth of cut. A finish of 70-125 rms with an average of 90 may be expected for cuts up to 0.250 in. deep. For cuts greater than 0.250 in., the range is 80-160 rms with an average of 115. In aluminum, surface imperfections are reproduced but not enlarged.
- **Magnesium:** A smooth satin, or smooth shiny surface of rms 30-70, average 50, can be expected on magnesium parts. Surface imperfections tend to "wash out" or disappear during processing.
- **Steel:** A smooth surface, shiny or satin finish, of rms 30-250 may be obtained in steel, depending on alloy, heat-treatment, and depth of cut.
- **Titanium:** A smooth, shiny surface of rms 15-50 is obtained on titanium. The average is 25 rms.

Materials: For parts that are to be chemically milled from aluminum, bare material rather than alclad should be specified whenever possible. Bare material gives better line definition and fillet radii. When optimum line definition and/or radii are important, yet alclad is required, the cladding can be removed from one side by chemical milling.

Chemically milled fillet radii in unclad aluminum are approximately 90 deg, Fig. 6*a*, whereas the fillets in alclad stock approach a chamfer, Fig. 6*b*.

Stock should be of the same heat and, if possible,

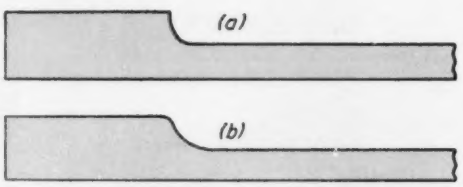
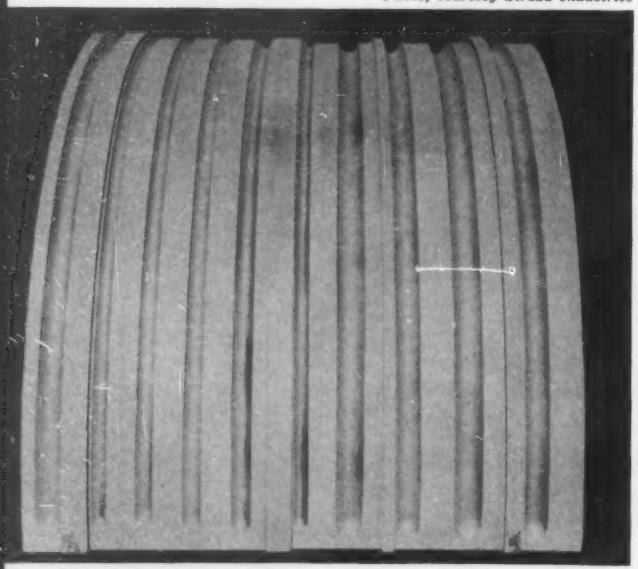


Fig. 6—Comparison of fillets in chemically milled bare aluminum, *a*, and alclad material, *b*.

Photo, courtesy Straza Industries



Heavy Chromalloy stator case is formed (approximately 3 ft diam), then chemically milled. Depth of cut is 0.80 in.

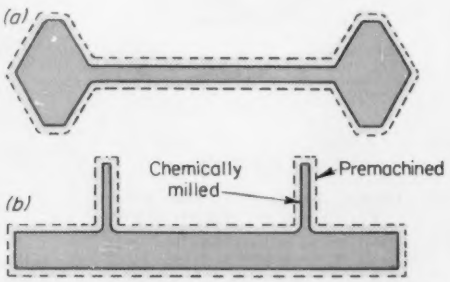


Fig. 7—Over-all size reduction by chemical milling of *a*, forged part, *b*, premachined part.

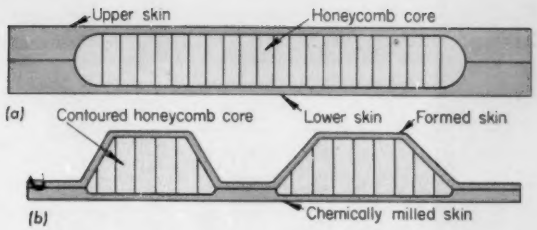


Fig. 8—Chemically milled skins, *a*, and cores, *b*, for honeycomb assemblies.

of the same mill run for each group of parts processed, to insure uniformity of physical and chemical structure and close tolerance control.

Parts should be formed and, when necessary, heat treated prior to chemical milling.

Trim: Whenever possible, parts to be chemically milled should be designed with an allowance for trim at the edges. Trimming the part after milling is usually much less expensive than protecting the edge (necessary when no trim is allowed) for processing. Recommended minimum trim allowance is $\frac{3}{8}$ in. plus depth of milled cut.

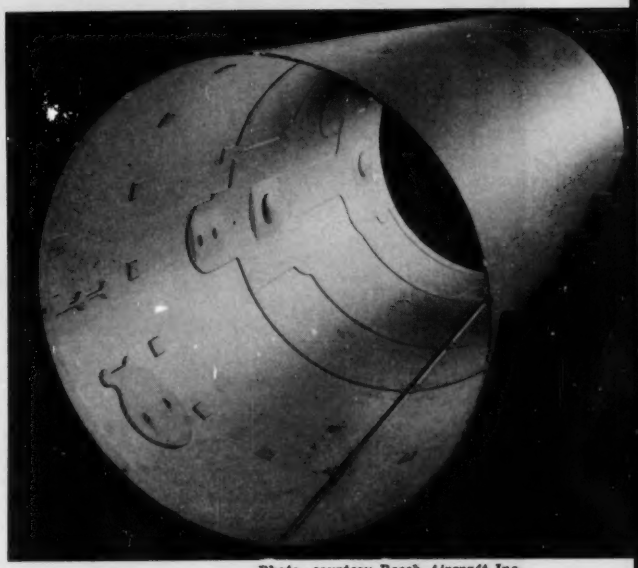
Application

Chemical milling applications vary from simple cuts to complex tapers and patterns. Entire surfaces of parts are often reduced to provide thin sections unattainable by conventional methods.

Over-all Etching: Parts which must be forged, formed, or cast oversize because of process limitations may be reduced uniformly by chemical milling. For example, although the heavy portions of the forgings of Fig. 7*a* can be formed easily to the desired thickness, the thin center section may introduce tooling problems. The least expensive method of producing the desired part would be to: 1. Increase the size of the heavy ends by the amount that the thin section is oversize. 2. Reduce the entire forging by chemical milling.

Similarly, castings can be designed uniformly oversize, heat treated with little or no warpage, then chemically milled to achieve the desired final dimensions. The resultant surface finish can often be reduced from over 200 rms to 40-60 rms. Machined or extruded parts may also be reduced in this manner. The part shown in Fig. 7*b* is first machined oversize to provide vertical webs, then reduced all over by chemical milling to provide web sections which are thinner than can be machined.

Chemical Milling after Forming: Forming material that is uniform in cross section reduces the possibility of cracking, buckling, or oil-canning. Also, the cost



Photo, courtesy Beech Aircraft Inc.

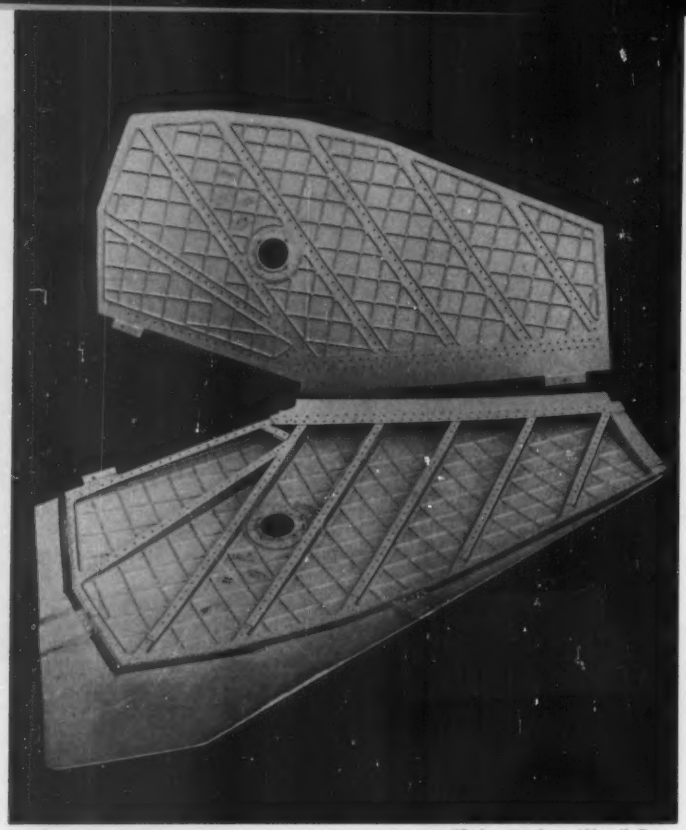
Chemical milling often eliminates the need for stiffeners and doublers normally required for structural stability. Part shown is for an external fuel tank for mounting on aircraft wing sections.

Photo, courtesy Altamil Corp.

Steel pressure-vessel hemispheres (AM 350 and 17-7 PH) have been chemically milled to reduce wall thickness from 0.080 to 0.030 in. Rim section is left heavier for welding purposes.

Photo, courtesy Norair Div., Northrop Corp.

Landing-gear door assembly for T-38 Talon trainer uses contoured honeycomb section produced by chemical milling. Core thickness varies from 0.030 to 0.670 in.



Photo, courtesy Altamil Corp.

Wing-tip skins for Convair F-106 are among the most complex parts chemically milled to date. Land widths are held to 0.040 in.—much narrower than those recommended for normal production practice. Deepest chemically milled cuts are 0.210 in.

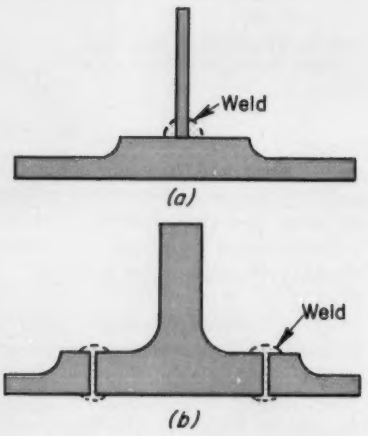


Fig. 9—Raised lands are used to accommodate welded joints in assemblies of chemically milled parts.

of check-and-straightening fixtures is greatly reduced when milling can be done after forming. Conventional machining of a formed part is difficult, and in many cases, impossible.

Honeycomb: Construction of honeycomb parts can be simplified by chemically milling the upper and/or lower skin so that attach points are integral, Fig. 8*a*. Chemical milling may also be used to shape the core, Fig. 8*b* to provide radius contours such as are required for fairings and airfoil leading edges. Narrow channels, sharp radii, and complex curves can be made without crushing the core.

Briefly, the honeycomb-shaping process consists of six steps:

1. A pattern is prepared which has the exact configuration desired for the core material.
2. From the master pattern, a "negative" is cast of a frangible, plaster-like, water-dispersible material.
3. The honeycomb core is pressed into the negative to the desired depth.
4. The exposed core is covered with a maskant to protect it from the action of the etchant.
5. The negative is removed and the newly exposed core is dissolved in the chemical milling etchant.
6. The maskant is removed from the part. (Some final dressing with fine emery paper may be necessary.)

Welded Construction: In weldments of chemically milled parts, a raised land is usually provided at butt-welded joints, Fig. 9*a* to afford strength in critical areas. Similarly, at a joint between a heavy structure and a thin skin, a raised land is recommended, Fig. 9*b*.

Mechanical Properties

When any new process for manufacturing structural components is developed, or changes are made in existing processes, a major design concern is the effect which the process innovation or revision has on the mechanical properties of the material processed. Although information on chemical-milling effects on all metals and alloys is not complete, tests on certain alloys in each class of materials are indicative of the low order of change in both static and fatigue characteristics from the parent material. Alloys and forms that have been chemically milled in production and limited-production quantities are listed in *Alloys and Forms for Chemical Milling.*

Aluminum: Standard mechanical property tests indicate that chemical milling has no appreciable effect on the compression, tension, or shear properties of aluminum alloys.

Extensive fatigue data have been submitted on sheet alloys of 2024-T3 and T4, 2014, 6061-T6, 7075-T6, and 7178-T6. Tests on 2024-T3 demon-

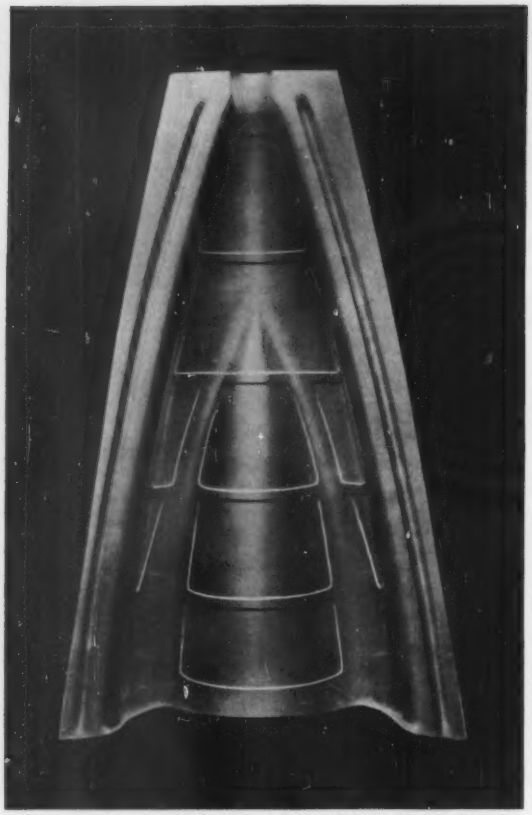
Alloys and Forms for Chemical Milling*

Alloy	Form										Condition
	S	P	B	R	Rd	Ex	T	D	F	C	
Aluminum											
1100			X								As received
2014			X	X	X	X			X		T4, T6
2014 Alcad	X	X									T4, T6
2020	X	X	X	X							T6
2024		X	X	X	X	X	X	X	X		T3, T4
2024 Alcad	X	X									T3, T4 T81, T86
2219	X										As received
3003	X										As received
5052	X	X	X	X			X	X			O
6061	X	X	X	X	X	X	X	X	X		O, T4, T6, T62
7075	X	X	X	X	X	X	X	X	X		O, T4, T6
7075 Alcad	X	X									O, T6
7079	X								X		T6
7178	X	X			X	X					O, T6
Magnesium											
AZ-31	X	X	X	X	X	X					O, H24
AZ-91										X	T4, T6
EK-41										X	T6
EZ-33										X	T5, T6
HK-31			X	X						X	H24, T4, T6
HM-21			X	X							T8
HM-31			X								F
HZ-32										X	T5
ZK-51										X	T8
ZK-60	X					X					As received
Iron											
1010	X	X									As received
1020	X	X					X				As received
4130	X										As received
4340	X								X	X	As received
6434	X										As received
301	X	X									Annealed, TH, RH
302	X										Annealed
304	X	X									Annealed
310										X	As received
316	X										Annealed

Alloy	Form										Condition
	S	P	B	R	Rd	Ex	T	D	F	C	
Iron (cont'd)											
321	X						X				Annealed
347	X									X	Annealed
410	X		X							X	Annealed
430	X										As received
PH 15-7 Mo	X		X						X		Annealed RH 950 RH 100
17-4 PH	X	X	X								Annealed
17-7 PH	X	X	X		X			X			Annealed THD. T. (180,000-200,000 psi)
19-9 DL	X										As received
350	X	X									Any condition
A286	X										As received
355	X	X	X	X							Any condition (except pickled)
Vascojet 1000	X		X								Annealed (280,000-300,000 psi)
Chromalloy		X									As received
Crucible 56											As received
HY-TUF			X								As received
Ladish D6 AC	X										As received
Multimet		X									As received
Thermold J			X							X	As received
Tricent											As received
Circle C			X								As received
Hi-speed			X								As received
Nickel-Cobalt											
Inconel	X										Any condition
Inconel W	X										As received
Inconel X	X	X	X	X					X		Any condition
Hastelloy	X										As received
Hastelloy X	X										As received
Rene' 41	X		X								Annealed
Titanium											
2.5 AL-16 V	X										As received
4 AL-4 Mn	X	X							X		As received
4 AL-3 Mo-1 V	X	X									Annealed, Aged
6 AL-4 V	X	X	X		X			X	X		Any condition
4 AL-3.5 Sn	X										As received
7 AL-4 Mo			X						X		Any condition
8 Mn	X										As received
Com. pure		X	X						X		As received

*Forms indicated by X have been chemically milled in production quantities. Etchants are under development for refractory and exotic alloys.

Key: S = sheet; P = plate; B = bar; R = rod; Rd = rolled; Ex = extrusion; T = tube; D = drawn; F = forging; C = casting.



Photo, courtesy North American Aviation Inc.

Fairing member for Navajo missile has integral stiffeners produced by chemically milling. Depth of cut on this 2024 alclad part is 0.080 in.

strate that the process does not reduce the fatigue life of either notched or unnotched specimens. Fatigue tests on 7075-T6, performed at high stress levels, show more favorable results for chemically milled material than for machine-milled material. Tests on 6061-T6 and 7178 show that chemical milling does not significantly affect the fatigue life of these alloys. Generally, chemically milled materials show greater uniformity of spread or range on the *S-N* curve than machine-milled materials.

Accelerated corrosion tests show that chemically milled materials are neither more nor less susceptible to corrosive attack than machine-milled alloys.

Magnesium: Fatigue tests on extrusions of AZ-31A and B, and on ZK-60A plate, in the range of 14,000-16,000 psi indicate no appreciable reduction in fatigue life when compared to machined specimens.

Iron and Nickel Alloys: Tests on 4340 steel show that chemical milling does not affect tensile properties. Compression and shear-test results for 17-7 PH steel in the THD 1075 condition indicate that chemical milling has no significant effect on these properties. Fatigue tests indicate no difference in the chemically milled and machine milled materials. No evidence of intergranular attack or hydrogen embrittlement was found within the specified control limits.

The tensile properties of PH 15-7 Mo Cres steel are not significantly lowered when chemical milling is performed after the refrigeration treatment (−100 F for 8 hr).

The tensile properties of PH 15-7 Mo Cres steel are not adversely affected by chemical milling in either the as-received or the RH 950 condition.

Chemical milling lowers ultimate tensile strength and per cent of elongation when AM 350 Cres steel parts are chemically milled in the as-welded and as-welded-and-heat-treated conditions.

Some hydrogen pickup has been traced in Vascojet 1000 and Thermold J alloys.

Mechanical property tests on machine-milled and chemically milled 6A1-4V titanium-alloy sheet show that chemical milling has no significant effect on these properties. Reverse-cantilever bending-fatigue tests on A-110AT titanium-alloy sheet conclude that the chemical milling process increases the hydrogen content of this alloy and decreases its fatigue life. Vacuum-annealing reduces the hydrogen content.

Hydrogen embrittlement is not a serious problem when chemically milling the 8 Mn titanium alloy if initial hydrogen content is kept below 80 ppm and the part is milled from one side only to a depth not over one-half of the original stock thickness. None of the other alloys of titanium pick up a significant amount of hydrogen as a result of chemical milling except the all-beta alloy, 13V-11Cr-3Al.

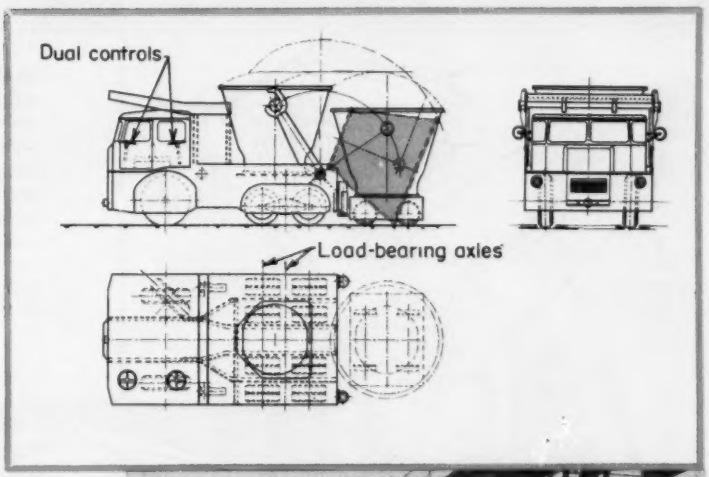
They Say . . .

Whenever and wherever a technological advance has taken place in our civilization, engineers have had a key role in bringing it to pass. And in each successive era, engineers have moved with the times. The great advances in scientific knowledge during recent decades have found them prepared for the opportunity to turn revolutionary discoveries to the uses of society. The conversion of atomic energy from theory to a great source of energy is a reality. Instrumented rockets and massive radiotelescopes extend man's senses, enabling him to probe the farther reaches of the universe. Currently, members of the profession are studying methods of making feasible still newer systems of energy conversion and are extending our communications network via satellites. In the case of a space rocket or superhighway, the engineer's contribution is obvious to all. But more of their contributions (like the submerged part of an iceberg) are not always apparent to the casual observer.—Edward E. Slowter, *Vice President, Battelle Memorial Institute.*

Hydraulic Handler Dumps Slag Pot

HYDRAULIC SUPPORTS keep vehicle from tilting while manipulating the heavy loads. Louvered aluminum screen protects the operator from intense heat of the slag.

MANIPULATING ARMS on a slag-pot truck use hydraulic power to lift slag pots that may weigh as much as 30 tons when full. Pots can be lifted from ground to truck body and back, or they can be tilted for pouring by catching the bottom of the pot on a hydraulically operated restraining mechanism. Truck was designed by Faun-Werke K Schmidt, Nuremberg, Germany.



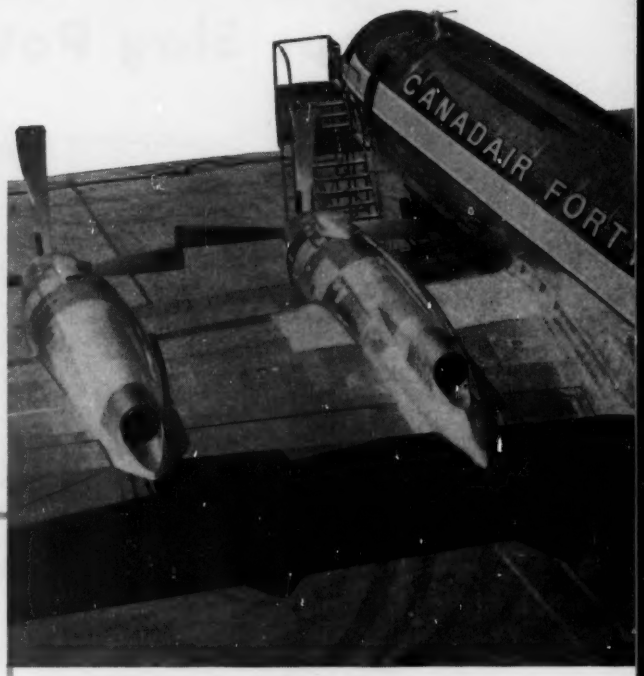
SOLID-RUBBER TIRES support the weight of the slag pot. They are arranged in four pairs on each of two load-bearing axles. Dual controls allow operator to face front or rear while operating the vehicle.

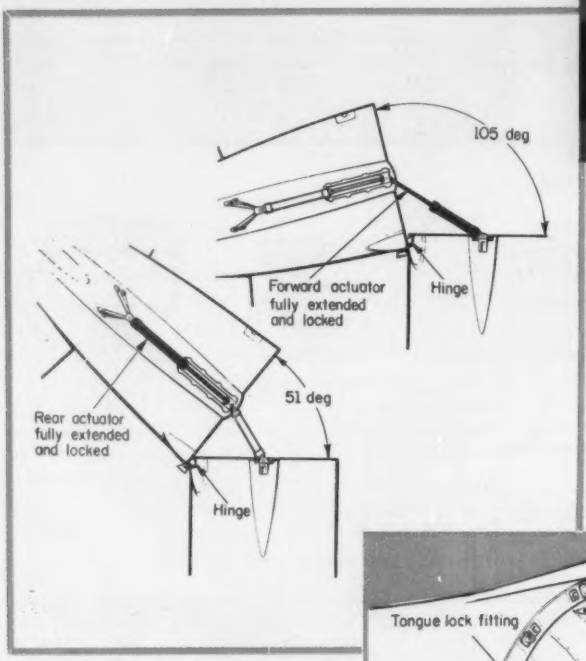
POWER for the truck comes from a 170-hp 8-cylinder diesel engine. Drive and steering are both done through the front wheels which are equipped with pneumatic tires.

Swing-Tail Freighter Power-

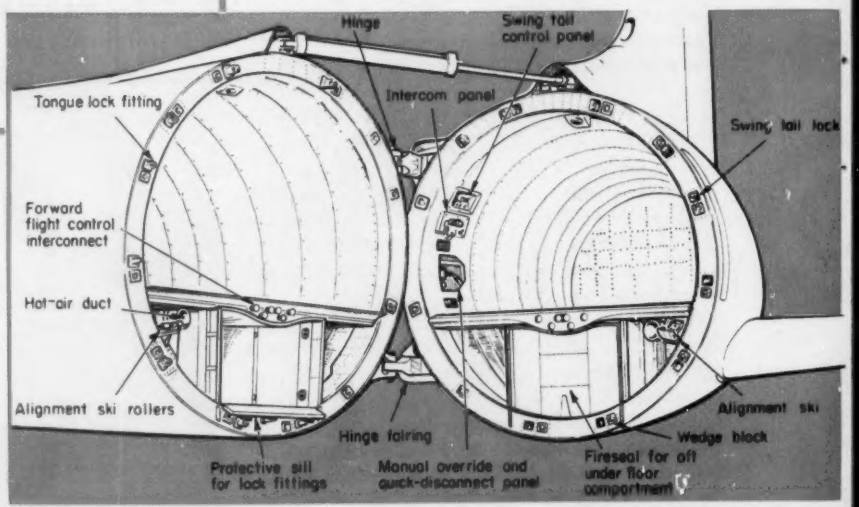
AUTOMATIC cargo-stowing system on Canadair's new "Forty Four" air freighter cuts terminal turn-around time to less than a quarter of that required by manual loading methods. Discounting the slight weight and bulk penalty of carrying some of the handling equipment on board, Canadair officials, working with cost and revenue figures for a hypothetical ten-plane fleet, show that increased flying time can nearly double profits.

Obvious feature of the new cargo-handling system is the swing tail. Push rods transmit elevator and rudder control across the break. Hydraulically operated latches hold the tail shut. A cut-off in the tail section keeps them from being accidentally open while the ship is in flight.





RAMP-AND-ROLLER system lines up mating edges during closing sequence. Final alignment is provided by wedge blocks mating with recesses next to each lock. Glass-fiber fairings cover the hinges, and an inflatable seal maintains cabin pressure. The eight locks each consist of a tongue on the main fuselage mating with a fork in the tail fuselage. Lock pins are engaged by individual hydraulic actuators. Internal mechanical locks provide a double safety.

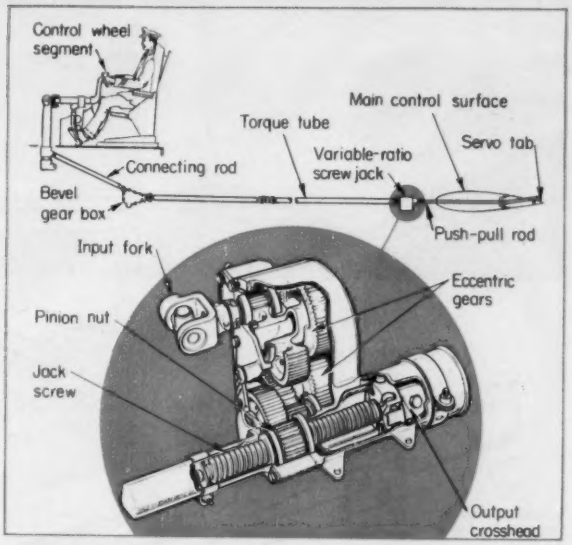


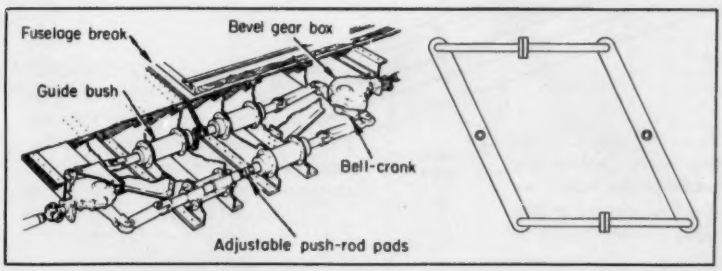
Loads Cargo

Controls

SWING-TAILED transport is the first aircraft specifically designed for 100 per cent cargo hauling. Power is supplied by four Rolls Royce Tyne 12 turboprops developing 5730 shp each. Tail opening is powered by two articulated hydraulic cylinders hidden in the dorsal fin. The tail swings through an arc of 105 degrees in 90 seconds.

CONTROL RUNS are aluminum torque tubes connected by universal joints. Bevel-gear ratio of 1:25 rotates torque tubes at a fairly high rate in comparison to the pilot's control motions. Breakaway and friction losses are kept to a minimum by this step up. Variable-ratio screw jacks change rotary motion of the torque tubes to the push-pull motion needed at the control surfaces. Eccentric gears change input-output ratio continuously, giving more positive control at the limits of motion where large angles reduce effectiveness of control motion.

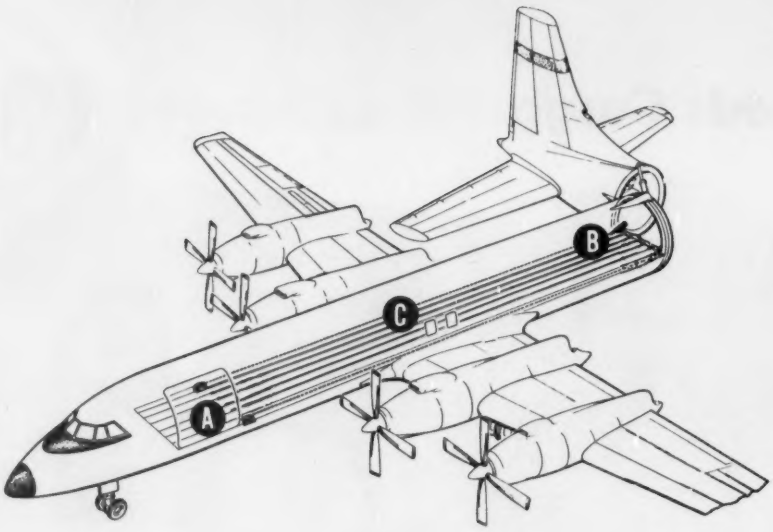


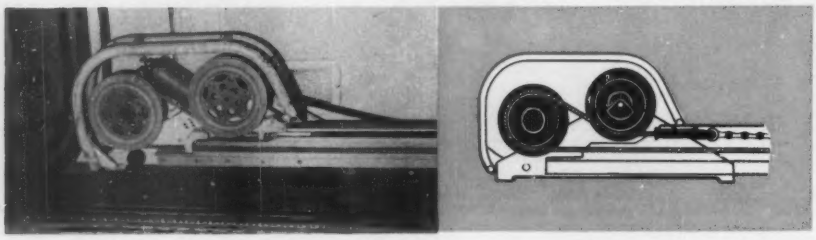


CONTROL DISCONNECTS at the hinged tail consist of two cranks each—one in the tail fuselage, and one in the main fuselage. Push rods in guide bushings furnish communication between the cranks. When the tail section is closed, push rods force the follower crank to the same position as the driver crank, thus passing on control signals.

Cargo Stowing

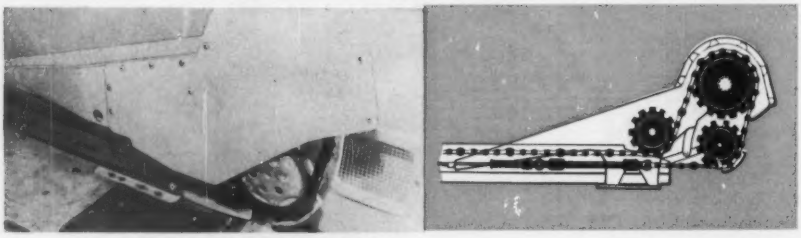
WINCHING system mounted in the main cargo compartment consists of two chain-and-cable loops running in tracks at the edges of the cargo floor. Loaded pallets are delivered to the rear opening and winched forward into position. Unloading is the reverse of this procedure. The pallet rides sled-like on rubbing strips in the compartment floor. These rubbing strips waste less space and weight capacity than the typical roller floor.





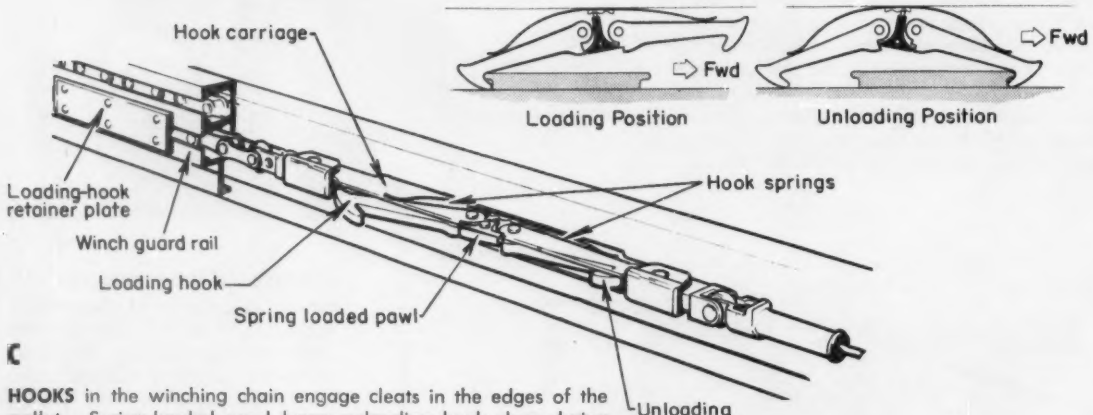
A

IDLER pulleys are mounted at inner end of cargo hold. Tension can be controlled with a spring-loaded cable tensioner.



B

DRIVE sprockets are mounted near the fuselage break. Splined drive pickup couples to winch drive on loading vehicle. Weight is saved by not having power for winching system aboard.

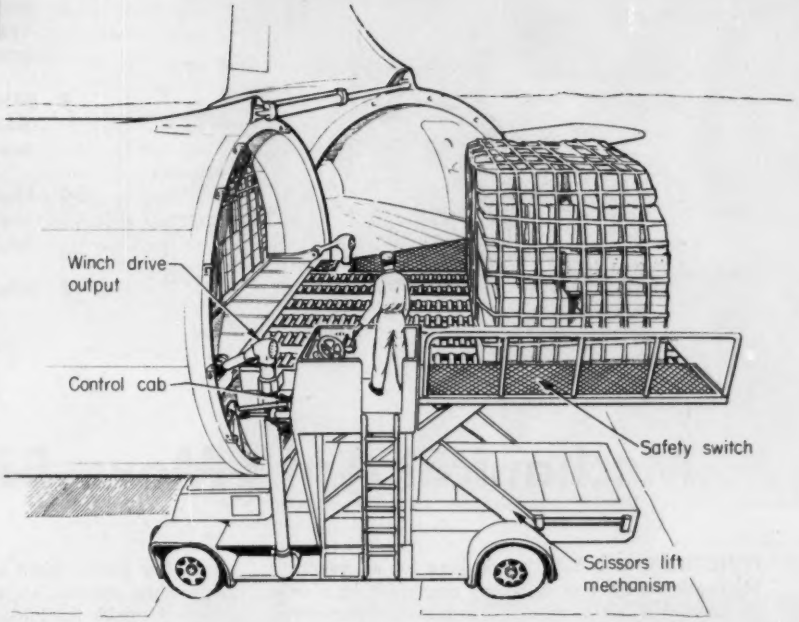


C

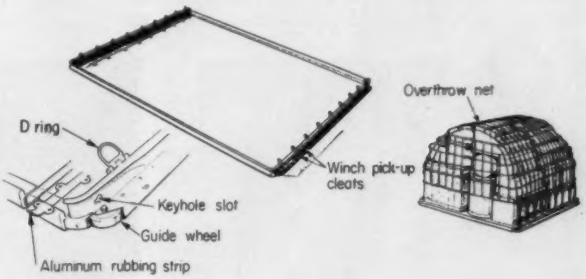
HOOKS in the winching chain engage cleats in the edges of the pallet. Spring-loaded pawl keeps unloading hook clear during loading operations. Cam surfaces on the backs of the hooks are designed to let them slide over the cleats when moved in the reverse direction. They engage automatically when moved in the operating direction.

Winching

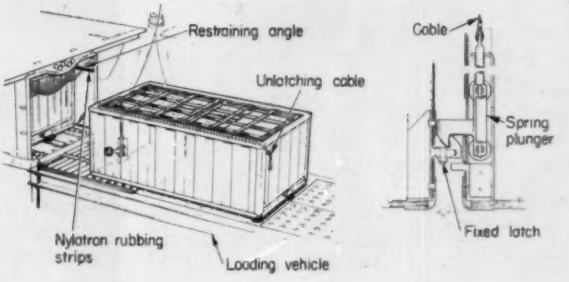
DRIVE for winching system comes from an auxiliary loading vehicle also designed by Canadair. Outputs from the vehicle couple to attachment lugs on winching system's drive sprockets. Scissors lift brings loading platform to cargo floor height. Power rollers move pallets forward to a position where winch hooks can engage them.



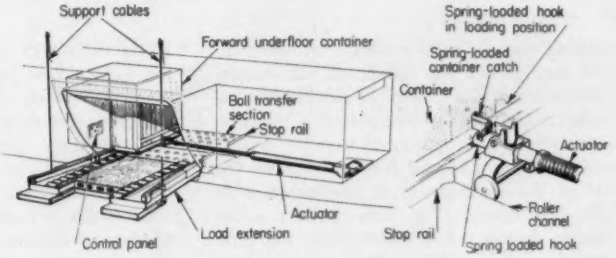
CARGO PALLET is a flexible aluminum sled designed for minimum bulk and weight. Aluminum rubbing strips slide on similar strips in the floor of the cargo hold. Guide wheels roll on the winching cable housing to keep the pallet centered. D-rings secure a lightweight nylon hold-down net that keeps the cargo from shifting.

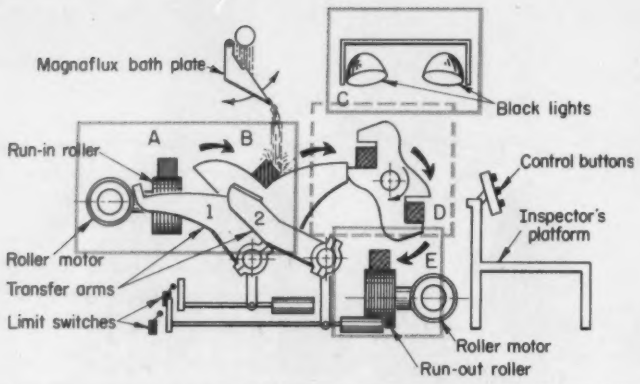


UNDERFLOOR compartments can be loaded with bulk cargo or containers. Containers are latched together train fashion to restrain them from forward or backward motion. Vertical motion is inhibited by restraining angles on each side of the compartments.



FORWARD underfloor compartment must be side loaded. A hydraulic actuator speeds the process. Spring-loaded hook is tipped up while loading. For unloading it engages container latches to drag containers to the ball transfer section.





Sequence

A Billet enters on run-in rollers. Transfer arm 1 moves it to V-groove B.

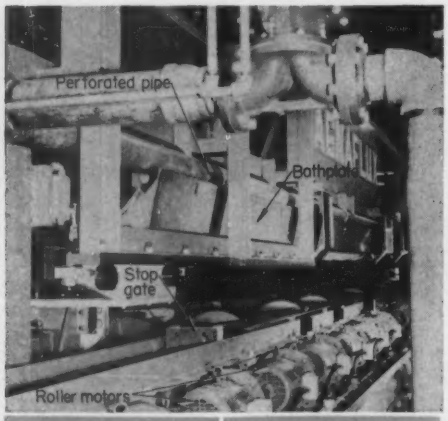
B Billet is clamped by electrodes and flooded by bath plate. Transfer arm 2 moves it to rotating arm.

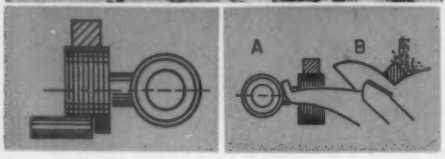
C-D Black light excites particles to show flaws clearly. Two stations let inspectors see all four sides.

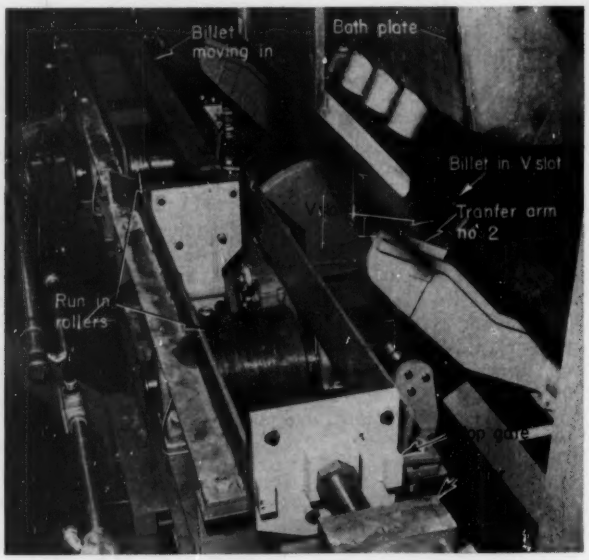
E Billet leaves on run-out rollers.

Mechanical Arms Move Billets through

FUNCTIONS of a billet manipulator for an automatic Magnaglo line are kept in orderly progression by a series of interlocked servo circuits. The manipulator moves heavy billets through a blacklight inspection process that includes magnetizing, flooding, and inspection stations. The system, through appropriate circuits, also controls motion of the billets before they reach the machine and after they leave. Limit switches initiate any operation only when the next stage has cycled. This assures an empty berth for the in-coming billet. Inspectors examine treated billets under ultraviolet lights at two stations (two sides at each station). After marking flaws, they select future route of the billets by pushing one of three disposition buttons on the inspector control panel.

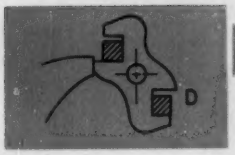




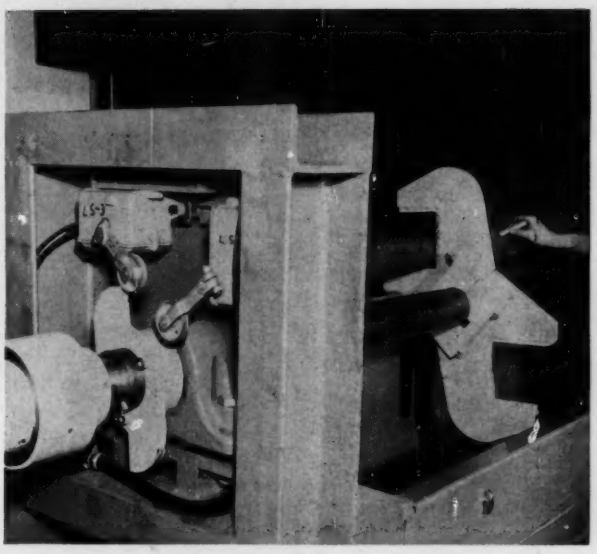


INDIVIDUAL squirrel-cage motors operate run-in and run-out rollers. The rollers run continuously. Progress of the billet is determined by stop gates. Gate in the foreground is released to admit a billet by cycling of transfer arm 1. Magnetic bath is pumped from a tank in the bottom of the machine to a perforated pipe over the bath plate. The bath plate, a wide, flat nozzle, swings on a center near the pipe to flood the billet evenly with a smooth sheet of water containing luminescent particles.

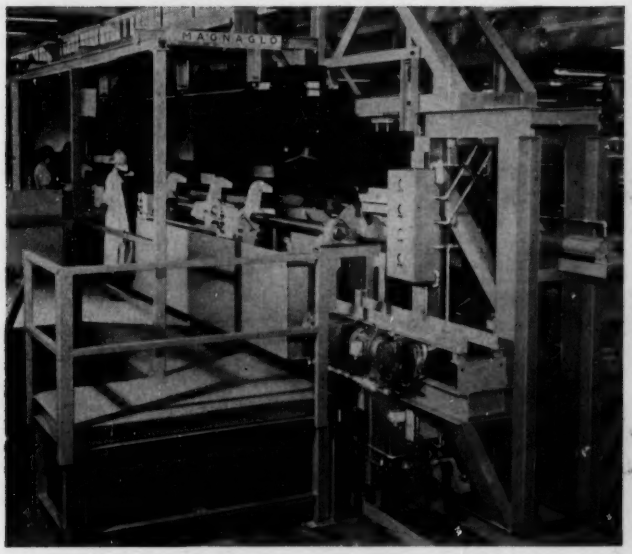
PNEUMATICALLY operated transfer arms move the billet from the run-in rolls to the treating stage (V slots), where it is magnetized and flooded, and from there to the rotating arms for inspection. Magnetic fields are produced in the bar by high-amperage current from electrodes (not shown) that clamp the billet by the ends while it rests in the V slots. Bath containing magnetized luminescent particles is flowed over the billet in a smooth stream by the bath plate.



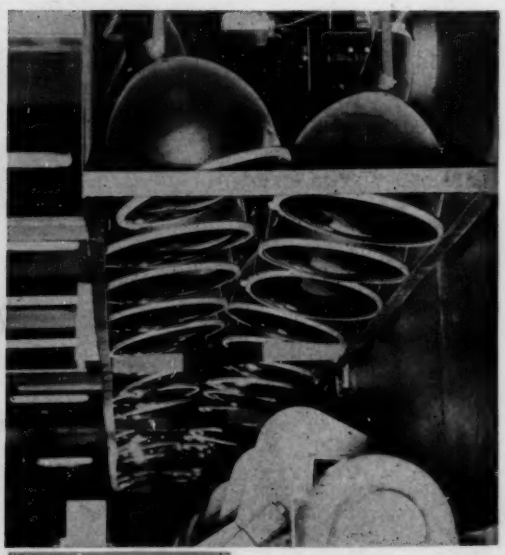
SQUARE CUTOUTS in the rotating arm hold billets. The arm rotates 180 degrees. Billet in the lower recess (empty in the picture) drops to run-out rollers; empty cutout moves to the upper position. Limit switch triggers the preceding stage when the empty recess is in position.

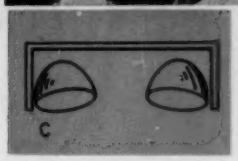


Black-Light Line

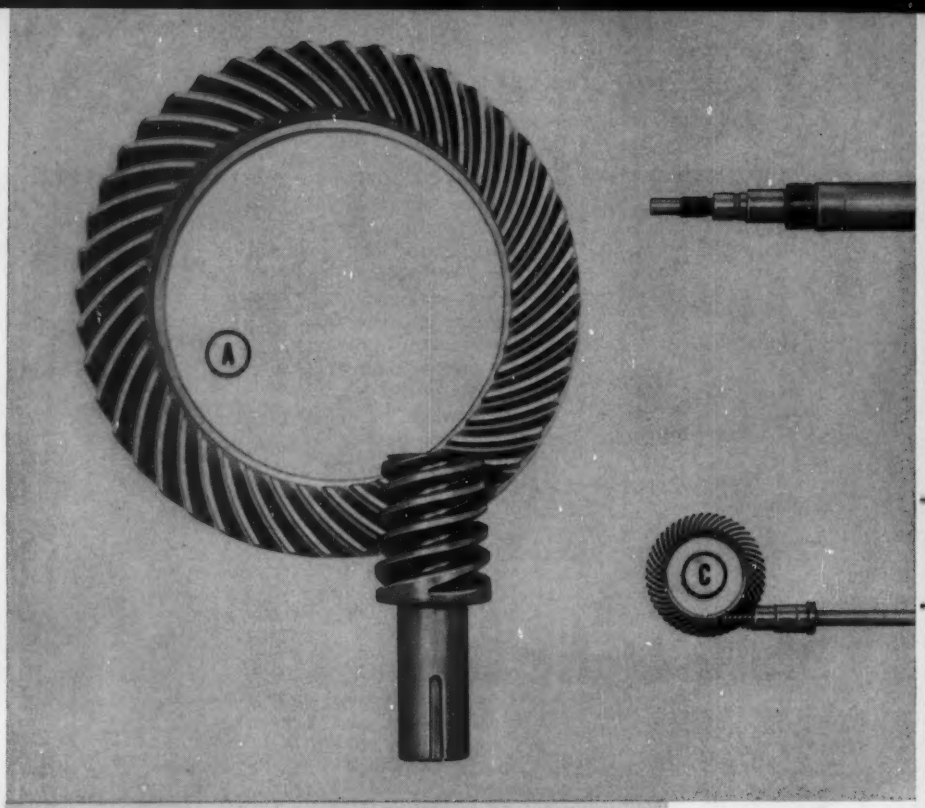


The Magnaglo inspection machine was designed and built by Magnaflux Corp., Subsidiary of General Mills, Chicago.





BATTERY of ultraviolet lights excites luminescent particles to show up surface cracks and defects. The inspector chooses a destination for the billet by pushing one of the buttons on the small panel at left. This triggers the entire sequence of manipulation and is the only manual operation needed.



A
Farm Machine — A 3:43 combination with gear of 14.5-in. OD and 3-in. shaft offset.

B
Machine Tool Drive—A 1:45 combination with gear of 8-in. OD and 2.25-in. offset. Both members have ground teeth.

C
Power Tool Drive—A 1:49 combination with gear of 3.5-in. OD and 1-in. offset.

D
Business Machine Mechanism—A 2:41 combination with gear of 1.5-in. OD and 0.4-in. offset.

High-Reduction Hypoids

Types

Applications

Simplified Design

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Chief Research Engineer
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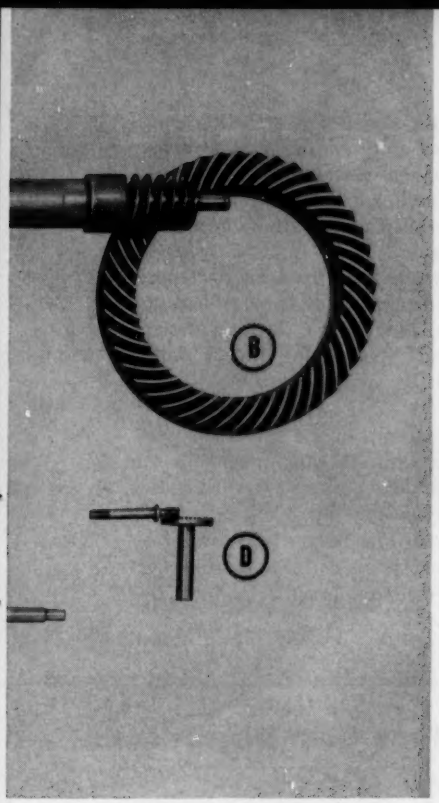


as a whole, dimensions of the finally chosen gear members can be found to any degree of exactness for specification on detail and production drawings.

Hypoid gears operate on nonintersecting nonparallel shafts. Geometrical relationships essential to the design of any hypoid gear set are defined by Fig. 1. The line of centers is mutually perpendicular to the axes; the distance between the axes along the line of centers is offset *E*. Shaft angle Σ is frequently 90 deg.

Gear OD is the primary reference dimension because it defines the over-all size of a gear set and because gear size may be limited by production facilities. Other defining quantities of a gear set are

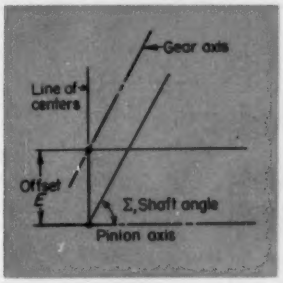


Fig. 1—Relationship of axes for hypoid gears.

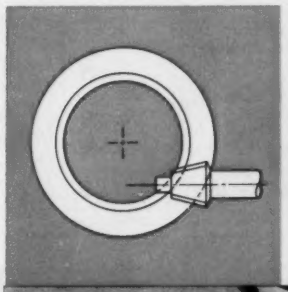
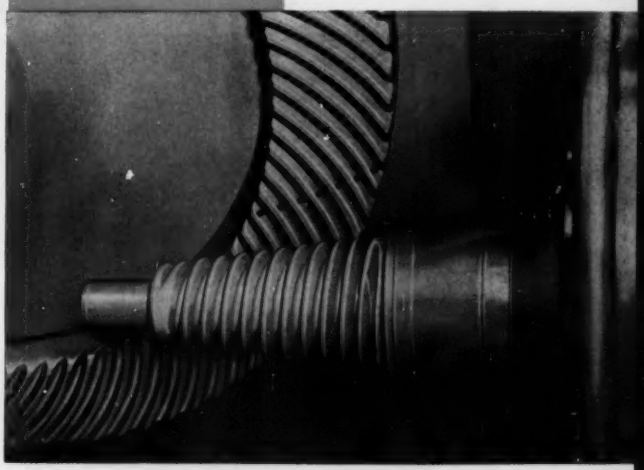


Fig. 2—A 2:90 combination with 13.25-in. gear OD, 2.00-in. pinion OD, and 3.50-in. shaft offset for a precision spindle drive. Contact marks on gear teeth indicate simultaneous mesh with pinion teeth.



SPEED-REDUCTION ratios as great as 360:1 can be obtained with a single hypoid gear pair. High-reduction hypoid gears, designated HRH, are a natural extension of Formate hypoid gears. Both HRH and Formate are Gleason trademarks; Formate identifies the tooth-forming method used for the basic gear member.

Reductions greater than 360:1 are possible if the pitch required is not too fine to be practical. Most HRH applications, however, have speed ratios between 10:1 and 120:1. This article explains and illustrates a simple procedure for designing HRH gear sets within this range.

None of the applications discussed here represents a departure from established hypoid design principles or manufacturing methods. For high ratios, simplifications permit the dimensions of any combination to be arrived at with a minimum of calculation.

Tabular values permit the dimensions of certain often-used combinations to be established simply by multiplication by the gear OD. These tables are applicable also in preliminary designs, layout studies, and in the preparation of final assembly drawings where dimensions within 1/16 or 1/32 inch are close enough. After the design of a machine is settled

N, n, and Σ. See Nomenclature. As a rule, offset E is chosen to suit the requirements of final design and manufacture, but it can be selected as an initial design requirement when necessary.

Two Types

Quite often, shape and proportions of a gear set are influenced greatly by adjacent machine elements, particularly the shafts, bearings, and the housing. Sometimes one shape is better suited to a given space and conditions of application than another. Thus, two types of HRH gears are available.

Taper Type: Pinion and gear blanks are conical, like regular hypoid pairs, Fig. 2. For a chosen taper of the gear blank, the taper of the pinion blank is calculated to maintain a constant depth of mesh across the face depending upon the amount of offset. Taper-type designs permit large shaft diameters at the back ends of pinions.

Table 1 contains design data for selected taper-type pairs with gear pitch angles standardized at 75 deg. Other pitch angles can be used. In design calculations, they merely replace the 75-deg entry in the calculation forms.

Crown Type: Combinations of the crown type are particularly suitable where the pinion shaft is to extend through the pinion proper to an inboard bearing or to other mechanisms, Fig. 3. Blank geometry is particularly simple. The pinion is a portion of a cylinder; the face and pitch surfaces of the gear are planes. Table 2 contains design data for se-

Table 1—Taper-Type Gear Dimensions

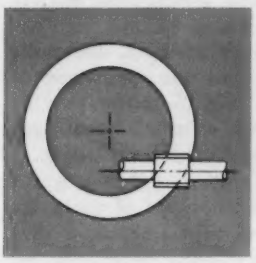
Gear ratio, m_G	12 1/4	14 2/3	17 1/3	21 1/2	25 1/2	31 1/2	38	47
Teeth on pinion, n	4	3	3	2	2	2	1	1
Teeth on gear, N	49	44	52	43	51	63	38	47
Offset, E (in.)	0.2000	0.2300	0.2400	0.2500	0.2700	0.2800	0.2900	0.3000
Whole depth, h_t (in.)	0.0321	0.0355	0.0304	0.0363	0.0309	0.0254	0.0409	0.0334
Gear OD, D_{GO} (in.)						1.0000		
Gear crown distance, X_C (in.)	0.0887	0.0899	0.0851	0.0775	0.0823	0.0783	0.0785	0.0799
Gear face width, F (in.)						0.1500		
Gear face angle, Γ (deg.)						75.00		
Pinion OD, D_{PO} (in.)	0.2356	0.2456	0.2262	0.2226	0.2224	0.2036	0.2344	0.2228
Pinion inner crown distance, B_i (in.)	0.2826	0.2614	0.2557	0.2437	0.2278	0.2219	0.1996	0.1932
Pinion outer crown distance, B_o (in.)	0.4674	0.4587	0.4531	0.4508	0.4396	0.4330	0.4333	0.4252
Pinion face angle, γ (deg)	13.42	12.80	12.60	12.35	11.88	11.50	11.33	11.00
Gear spiral angle, ψ (deg)						40.00		
Pinion spiral angle, ψ_P (deg)	67.50	71.75	73.50	75.00	78.40	80.00	81.75	83.50
Pressure angle, ϕ (deg)						20.00		

Table 2—Crown-Type Gear Dimensions

Gear ratio, m_G	10 1/4	12 1/4	14 2/3	17 1/3	21 1/2	25 1/2	31 1/2	38	47
Teeth on pinion, n	4	4	3	3	2	2	2	1	1
Teeth on gear, N	41	49	44	52	43	51	63	38	47
Offset, E (in.)	0.2000	0.2000	0.2500	0.2500	0.3000	0.3000	0.3333	0.3333	0.3333
Whole depth, h_t (in.)	0.0360	0.0286	0.0355	0.0288	0.0389	0.0320	0.0274	0.0448	0.0356
Gear OD, D_{GO} (in.)							1.0000		
Gear crown distance, X_C (in.)	0.0880	0.0830	0.0792	0.0780	0.0693	0.0683	0.0681	0.0603	0.0608
Gear face width, F (in.)	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300	0.1300
Pinion OD, D_{PO} (in.)	0.2397	0.2162	0.2211	0.2067	0.2069	0.1930	0.1840	0.1993	0.1840
Pinion inner crown distance, B_i (in.)	0.2943	0.2979	0.2541	0.2561	0.1934	0.1965	0.1385	0.1385	0.1385
Pinion outer crown distance, B_o (in.)	0.4867	0.4836	0.4707	0.4671	0.4494	0.4448	0.4222	0.4329	0.4267
Minimum pinion mounting distance, B_M (in.)	0.5260	0.5139	0.5001	0.4904	0.4736	0.4645	0.4364	0.4551	0.4439
Gear spiral angle, ψ (deg)	41.45	45.00	37.69	40.83	32.03	34.55	29.42	30.56	32.49
Pinion spiral angle, ψ_P (deg)	68.82	72.37	72.77	75.91	75.63	78.15	79.44	80.58	82.51
Pressure angle, ϕ_1 (deg)							10		
Pressure angle, ϕ_2 (deg)							30		

lected crown-type pairs.

The large pair of Fig. 3 is used where accuracy of motion transmission and rigidity of mountings are prime considerations. The 4.5-in. offset is small in comparison with what it could be for a gear of 31-in. OD. It is great enough to provide both a pinion of practical size and ample room for straddle mounting the shaft on bearings. Pinion OD is 1.98



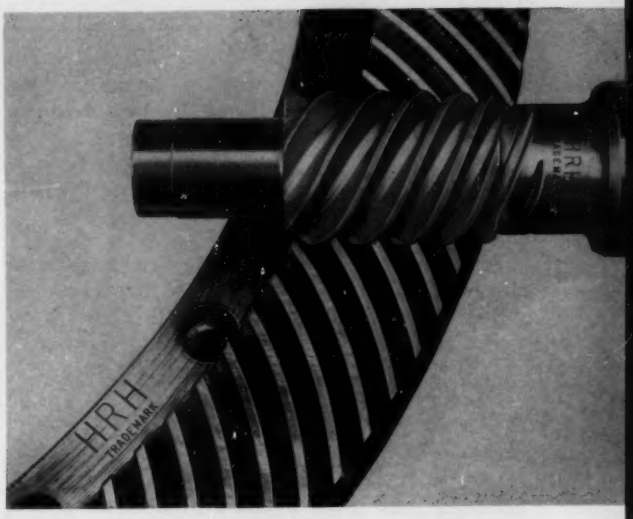
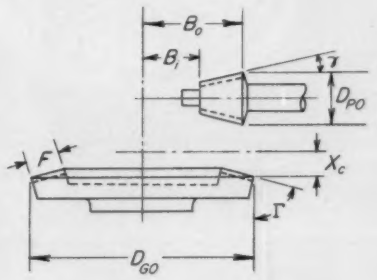


Fig. 3—Precision 5:150 combination with 31-in. gear OD, 1.98-in. pinion OD, and 4.50-in. shaft offset for a machine-tool drive.

(For Gear OD of Unity and 90 deg Shaft Angle)

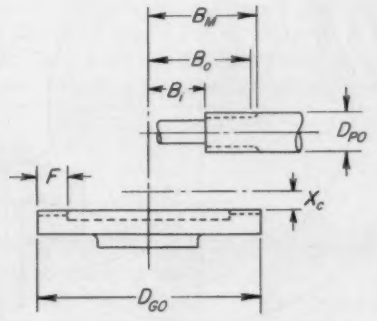
58	71	87	106	Gear ratio, m_G
1	1	1	1	Teeth on pinion, n
58	71	87	106	Teeth on gear, N
0.3000	0.3100	0.3100	0.3100	Offset, E (in.)
0.0276	0.0228	0.0190	0.0159	Whole depth, h_t (in.)
				Gear OD, D_{GO} (in.)
0.0683	0.0764	0.0644	0.0563	Gear crown distance, X_C (in.)
				Gear face width, F (in.)
				Gear face angle, Γ (deg)
0.1878	0.1914	0.1632	0.1407	Pinion OD, D_{PO} (in.)
0.1974	0.1884	0.1911	0.1934	Pinion inner crown distance, B_i (in.)
0.4230	0.4152	0.4137	0.4125	Pinion outer crown distance, B_o (in.)
11.00	10.70	10.70	10.70	Pinion face angle, γ (deg)
				Gear spiral angle, ψ (deg)
83.50	85.30	85.30	85.30	Pinion spiral angle, ψ_P (deg)
				Pressure angle, ϕ (deg)



For linear dimensions, multiply tabular values by gear OD.

(For Gear OD of Unity and 90 deg Shaft Angle)

58	71	87	106	Gear ration, m_G
1	1	1	1	Teeth on pinion, n
58	71	87	106	Teeth on gear, N
0.3333	0.3333	0.3333	0.3333	Offset, E (in.)
0.0283	0.0229	0.0185	0.0151	Whole depth, h_t (in.)
				Gear OD, D_{GO} (in.)
0.0672	0.0697	0.0700	0.0718	Gear crown distance, X_C (in.)
0.1300	0.1300	0.1150	0.0944	Gear face width, F (in.)
0.1840	0.1794	0.1724	0.1700	Pinion OD, D_{PO} (in.)
0.1385	0.1385	0.1703	0.2092	Pinion inner crown distance, B_i (in.)
0.4228	0.4187	0.4142	0.4110	Pinion outer crown distance, B_o (in.)
0.4364	0.4295	0.4235	0.4188	Minimum pinion mounting distance, B_M (in.)
34.00	35.16	37.39	39.71	Gear spiral angle, ψ (deg)
84.02	85.18	86.26	87.11	Pinion spiral angle, ψ_P (deg)
				Pressure angle, ϕ_1 (deg)
				Pressure angle, ϕ_2 (deg)



For linear dimensions, multiply tabular values by gear OD.

in. A larger offset ratio would mean an increase in sliding action between the teeth and a reduction in efficiency during operation.

Basic Member—the Gear

For either type, the gear is the basic member of a combination. Tooth surfaces are simple conical surfaces of revolution; hence, a tooth profile is an element of a cone, that is, a straight line. The teeth are form-cut or ground by the Formate process of conventional hypoid gears, Fig. 4.

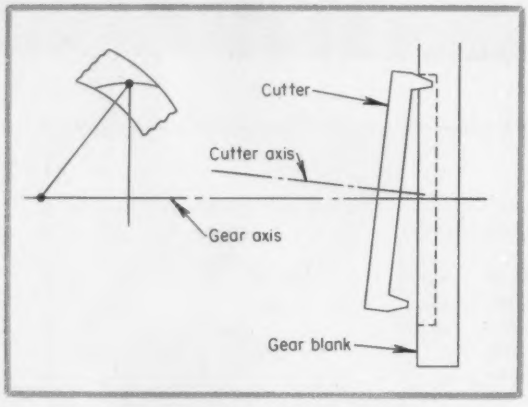


Fig. 4—Relationship of cutter to gear blank during cutting of Formate gear.

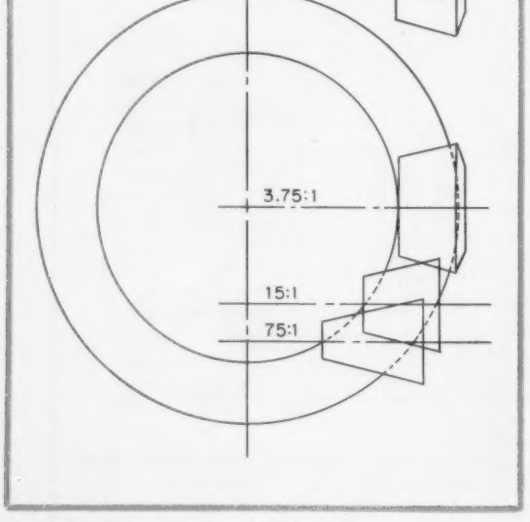


Fig. 5—Same gear meshes with different pinions at different ratios and offsets.

Conical tooth surfaces can be produced accurately and inexpensively. Since there is no generation of tooth shape on the gear, the cutting or grinding action is independent of tooth design. A cutting tool can be large and can be sharpened with correct rake angles for the material being cut. Likewise, a grinding wheel and the equipment for dressing it can be large. These conditions prevail even for fine pitch gearing.

Since the gear is the basic member, the same gear can be used in more than one application at different ratios and offsets. Fig. 5 shows possible arrangements, which include a spiral bevel pair. Fig. 6 shows an interesting "dual" application.

Significance of various design parameters is revealed by a review of some principles of conjugate gear-tooth action. It is generally recognized that any reasonable tooth surfaces may be chosen for one member of the pair, and the conjugate surfaces generated on the mating member. When this is done, the surfaces of action for the two sides are likewise determined, and the design of the gear and pinion blanks must be related to the surfaces of action in such a way that the best use is made of available tooth areas. The objective is a large contact ratio, without undercut or pointed teeth.

Nomenclature

D_{GO} = Gear outside diameter, in.
D_{PO} = Pinion outside diameter, in.
E = Shaft offset, in.
F = Face width, in.
F_{tG} = Gear tangential force, lb
F_{tP} = Pinion tangential force, lb
k = Pinion enlargement factor
m = Velocity ratio
$= n/N$
m_G = Gear ratio
$= N/n$
n = Number of teeth in pinion
N = Number of teeth in gear
R = Mean pitch radius of gear, in.
R_P = Mean pitch radius of pinion, in.
V = Linear velocity with subscripts, in. per sec
V_s = Sliding velocity, in. per sec
Γ = Pitch angle, face angle, and root angle of gear, deg
γ = Pitch angle, face angle, and root angle of pinion, deg
ε = Offset angle, deg
Σ = Shaft angle, deg
ϕ = Pressure angle, with subscripts 1 and 2 when pressure angles differ on opposite sides of tooth, deg
ψ = Gear spiral angle, deg
ψ_P = Pinion spiral angle, deg

Pinion Generation: The pinion is generated on a typical hypoid generating machine; the cutting tool, similar to that used for the gear, represents a tooth on the gear and envelops the desired pinion tooth. Theoretically conjugate pinions can be readily generated by this method, but it has been found desir-

able to introduce a slight ease-off of the tooth surfaces toward each end of the thread to permit good contact to be maintained under load. Independent control of pressure angle and spiral angle on each side of the teeth insures that optimum contact will be achieved without expensive tooling changes.

Fig. 7 shows the relative size of the cutter to the pinion and gear of a 1:360 ratio pair.

Teeth in Contact: By relating the diameter of cutter used for the gear to the spiral angles and to the pitch angles of the blanks, optimum contact ratio can be achieved. Fig. 2 shows the actual contact marks which exist at a particular instant on the gear of a typical pair. For this photograph, the teeth were painted with a marking compound and the pair brought into engagement without rotation under light pressure. The teeth were then disengaged without rotation and turned slightly to bring the marks into view.

Facts about High-Reduction Hypoids

- Gears operate on nonintersecting nonparallel shafts. Generally the shafts are perpendicular but other shaft angles can be used.
- The gear is the basic member of a combination. A gear blank is simple geometrically. Its tooth profiles are straight lines. The tooth surfaces are simple conical surfaces of revolution. Teeth are form-cut or ground by the Formate process of conventional hypoid gears.
- Pinion blank is either cylindrical or conical, depending upon type of combination. Pinion teeth are finish cut or ground on conventional hypoid-pinion finishing machines for conjugate tooth shape with teeth on mating gear.
- Number of teeth in contact is large. This characteristic and ground teeth on both members combine to make possible the highest quality of precision in motion transmission.
- Gear is right-hand and pinion is left-hand when the pinion is below center and to the right. For pinion offset above center and to the right, the gear is left-hand and the pinion right-hand. In either case, the pinion spiral angle is larger than the gear spiral angle by an amount that depends upon the amount of offset.

▶ Geometrical Elements

Important relationships of shaft offset to pinion diameter and lengthwise tooth sliding can be shown by a study of tooth action in the pitch plane. In crown-type pairs, the pitch plane is simply the plane of rotation of the gear that contains a point M designated at the pitch point, Fig. 8. Point M is located arbitrarily, and near the center of the face width of the gear. Angle ε is the offset angle. From the diagram,

$$\sin \varepsilon = \frac{E}{R} \qquad (1)$$

$$\psi_P = \psi + \varepsilon \qquad (2)$$

Thus, the difference in spiral angle on the two members is simply related to the shaft offset.

Fig. 9 is an enlarged view of the region of the pitch plane near pitch point M. Vector V_G is the velocity of the gear at M, and V_P is the velocity of the pinion. For unit angular velocity of the pinion in radians per second, the angular velocity of the gear is $m = n/N$; hence, $V_P = R_P$ and $V_G = mR$.

Since normal velocities V_n of gear and pinion must

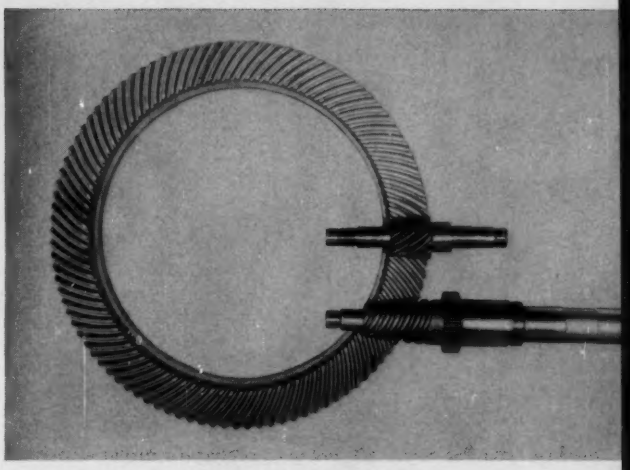
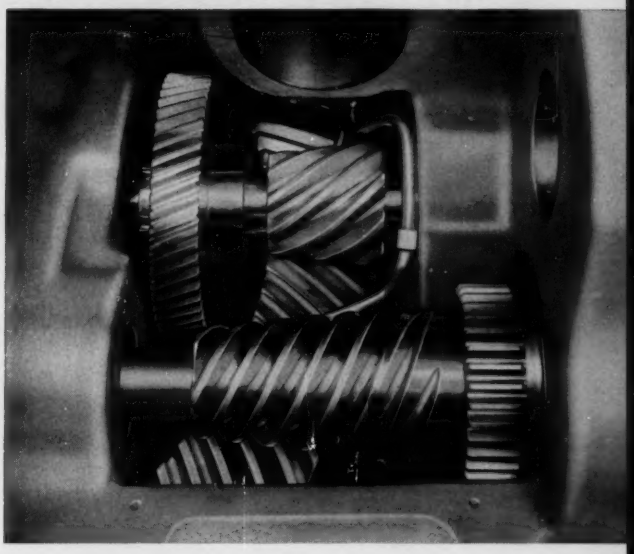


Fig. 6—Two pinions in machine tool mesh with same gear in compact assembly, one being a 5-tooth HRH pinion and the other a 9-tooth spiral bevel pinion running on center.



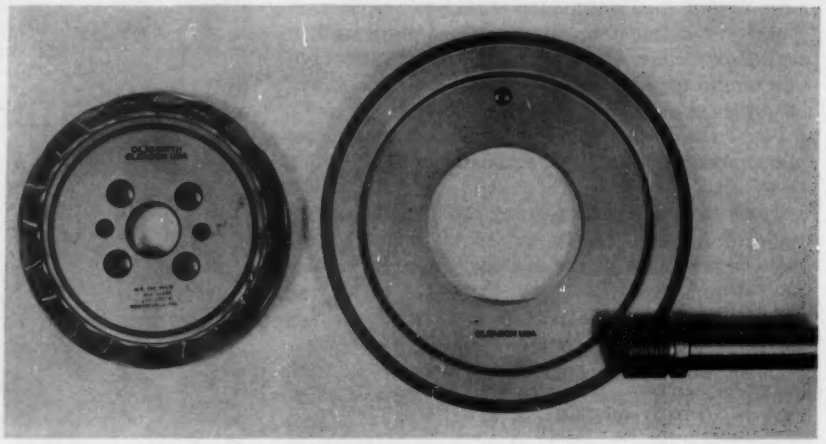


Fig. 7 — Relative cutter sizes for gear and pinion of 1:360 combination. Gear OD is 7.00-in., pinion OD is 1.06-in., and pitch is 51.4.

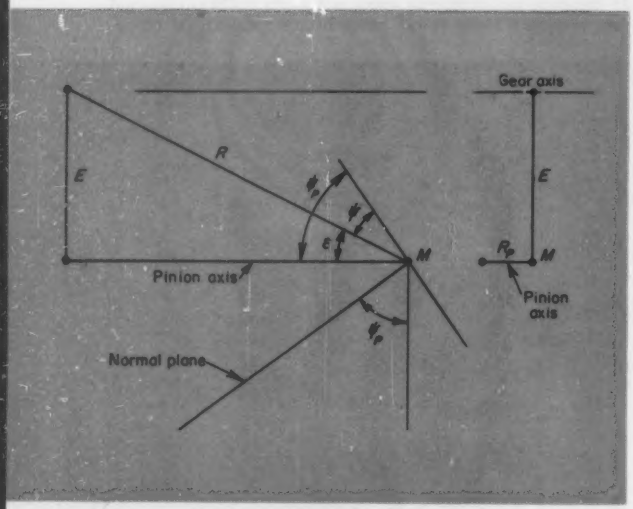


Fig. 8—Pitch plane geometry of crown-type HRH gears.

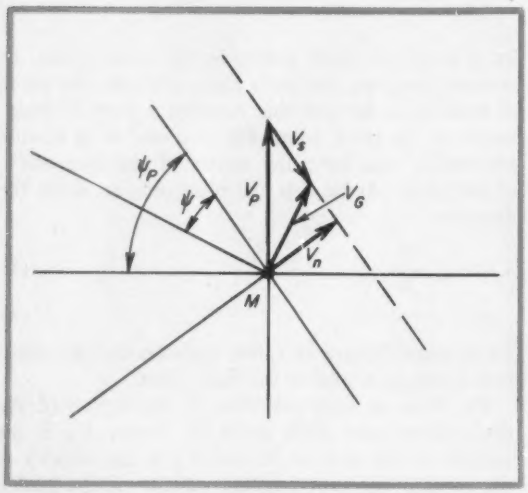


Fig. 9—Velocity relationships at pitch point in pitch plane.

be equal, the basic formula for hypoid contact is

$$R_P \cos \psi_P = m R \cos \psi \qquad (3)$$

Vector V_s is the lengthwise sliding velocity, which is

$$V_s = m R \cos \psi \ (\tan \psi_P - \tan \psi)$$
$$= R_P \cos \psi_P \ (\tan \psi_P - \tan \psi) \qquad (4)$$

for unit angular velocity of the pinion.

Analogous relations exist for taper-type pairs.

Pinion Size Determination: While hypoid offset has design advantages, such as passing shafts, the principal reason for adopting hypoid gears for high reductions is to get pinion diameters of practical sizes. For example, a bevel gear pair with a 3-in. gear at a ratio of 100:1 would require a pinion diameter of only 0.030-in.—obviously impractical. With hypoid gears, the pinion size can be 0.400 in.

Equation 3, which gives the relation for hypoid pinion size, can be rewritten:

$$k = \frac{R_P}{mR} = \frac{\cos \psi}{\cos \psi_P} \qquad (5)$$

where k is the "enlargement factor." Enlargement factor is the ratio of the hypoid pinion size to the size of a spiral bevel pinion of the same ratio.

Fig. 10 shows how this enlargement factor varies with offset and spiral angle over the range ordinarily used. It is noteworthy that

1. Pinion size increases with offset.
2. Pinion size increases with spiral angle.

This graph is useful in determining approximate size relationships prior to using the design tables or the calculation forms to get exact dimensions of a gear set.

▶ Design Procedure

Shaft angle, gear diameter, velocity ratio, pinion size, and shaft offset are the principal factors involved in the design of a gear set. Some of these

quantities usually are firmly established; others, depending on the nature of the problem, are subject to some choice. Shaft angle is fixed first in the design of a gear pair. It is usually 90 deg. The tables here are based on that shaft angle.

Gear diameter is usually settled next. Normally, it is chosen on a basis of space requirements and the load to be transmitted. Naturally, gear diameter should be large enough to provide a practical pitch. Also, maximum gear size and maximum offset may be limited by the capacity of available gear-cutting equipment.

Sometimes velocity ratio must be exact. In other applications velocity ratio need be only approximate. It governs the selection of numbers of teeth.

Where considerable design freedom exists, use

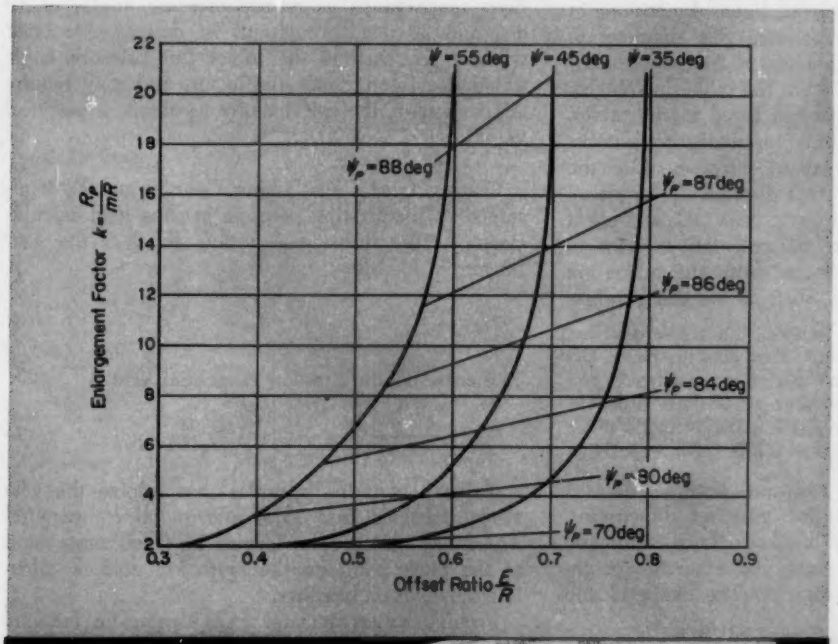


Fig. 10—Pinion size, offset, and spiral angle relationships.

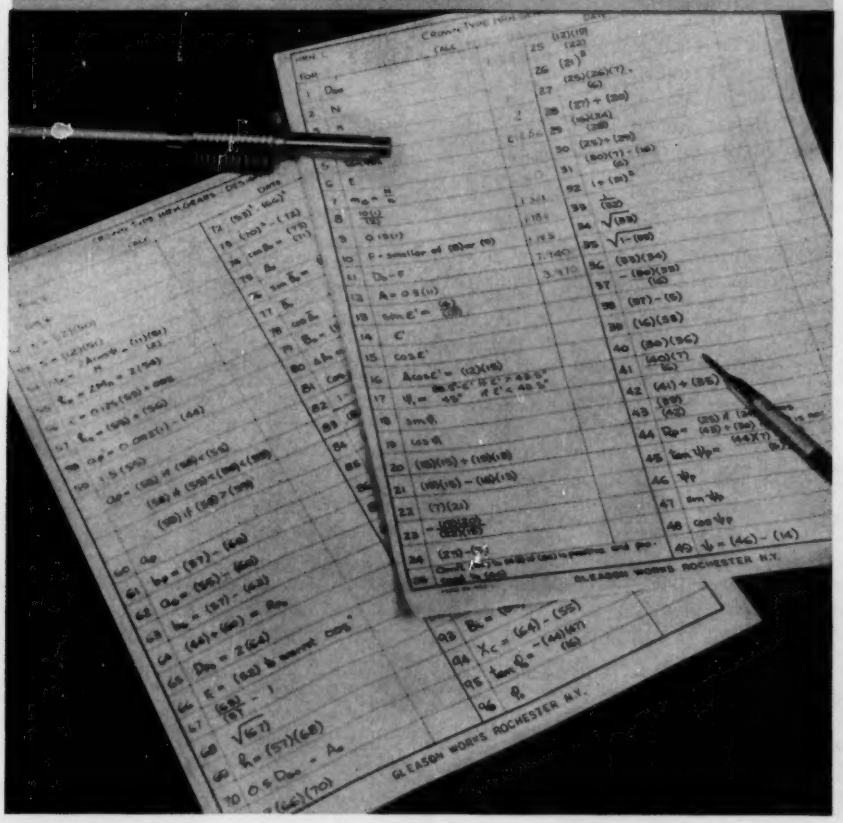


Fig. 11 — Fill-in forms permit detailed calculations of any HRH gear pair.

of the design tables has the advantage that important dimensions of the set can be obtained directly. When requirements of ratio or offset are more restricted, prepared calculation forms, Fig. 11, permit calculations based on any desired values.

Use of Tables: If a gear ratio corresponds to one listed in the tables, multiply all linear dimensions in that ratio column by the selected gear diameter to get the required design dimensions. Angular dimensions, of course, are taken from the table unchanged.

When a required ratio is not listed in the tables, interpolate between columns to obtain dimensions sufficiently accurate for layout purposes. Use the calculation forms to get exact dimensions for detail drawings after numbers of teeth, gear OD, and offset have been fixed. Also use the calculation forms to find dimensions if those found from the tables are unsuitable for any reason, such as too much offset.

EXAMPLE: What offset can be used with a 4:49 combination and a gear OD of 9.50 in.? How does the pinion OD of the taper type compare with that of a crown type?

From Tables 1 and 2, the offset $E = 0.200\ (9.50) = 1.900$ in. for both types. From Table 1, $D_{PO} = 0.2356\ (9.50) = 2.238$ in. From Table 2, $D_{PO} = 0.2162\ (9.50) = 2.054$ in.

Drawing Details: The diagrams within Tables 1 and 2 aim mainly to define gear set dimensions. Methods of securing gear blanks to hubs, shaft and bearing mountings, tolerances, and other design details should follow the design practice for bevel and hypoid gears.

Spiral Angle: The spiral angle on each member is intimately related to the design of the hypoid pair, particularly in connection with pinion size and offset. The pinion spiral angle is larger than that of the gear by an amount dependent on the offset. Spiral angles are listed in the design tables to permit calculation of bearing loads.

Pressure Angle: The average pressure angle of a hypoid pair is not a theoretical factor in the design of HRH gears. However, the difference in pressure angle between the two sides does depend on the geometry of the particular pair, and must be chosen to insure symmetry of action. The taper-type designs of Table 1 have been chosen to require no pressure angle unbalance. This is not usually possible with crown-type design; hence, Table 2 has been prepared so as to use pressure angles of 10 deg and 30 deg throughout. In designs calculated without reference to the tables this pressure angle unbalance is an important factor, and may require adjustment of the spiral angle to obtain a practical value.

Bearing Load Calculations: Gear torque T_G is assumed as the starting point in bearing load calculations. At the mean gear radius R, then the gear tangential load is

$$F_{tG} = \frac{T_G}{R} \tag{6}$$

The corresponding pinion tangential load is

$$F_{tP} = \frac{F_{tG} \cos \psi_P}{\cos \psi} \tag{7}$$

Table 3 contains formulas that resolve the gear tangential load into axial and radial components. The forces and couples formed by these components at the pitch point on the tooth are used to calculate the loads on bearings.

Positive values of axial force denote an outward thrust; negative values denote an inward thrust. Similarly, positive values of radial force are directed towards the axis, while negative values denote a radial force away from the axis.

These formulas apply to both types of HRH gears, but it is clear that they are greatly simplified for crown-type pairs, where $\sin \gamma = \cos \Gamma = 0$ and $\cos \gamma = \sin \Gamma = 1$.

A sequel to this article will cover the design of high-reduction hypoids for strength and durability.

Table 3—Components of Tooth Load in Axial and Radial Directions

Member of Gear Pair	Hand of Spiral and Direction of Rotation	Axial Force (lb)	Radial Force (lb)
Pinion	LH and counterclockwise or RH and clockwise	$\frac{F_{tG}}{\cos \psi}(\tan \phi \sin \gamma - \sin \psi_P \cos \gamma)$	$\frac{F_{tG}}{\cos \psi}(\tan \phi \cos \gamma + \sin \psi_P \sin \gamma)$
	LH and clockwise or RH and counterclockwise	$\frac{F_{tG}}{\cos \psi}(\tan \phi \sin \gamma + \sin \psi_P \cos \gamma)$	$\frac{F_{tG}}{\cos \psi}(\tan \phi \cos \gamma - \sin \psi_P \sin \gamma)$
Gear	LH and counterclockwise or RH and clockwise	$\frac{F_{tG}}{\cos \psi}(\tan \phi \sin \Gamma + \sin \psi \cos \Gamma)$	$\frac{F_{tG}}{\cos \psi}(\tan \phi \cos \Gamma - \sin \psi \sin \Gamma)$
	LH and clockwise or RH and counterclockwise	$\frac{F_{tG}}{\cos \psi}(\tan \phi \sin \Gamma - \sin \psi \cos \Gamma)$	$\frac{F_{tG}}{\cos \psi}(\tan \phi \cos \Gamma + \sin \psi \sin \Gamma)$

SELF-CHECKING INTERPOLATION

. . . a simple, accurate method for finding an intermediate value from values already tabulated for a nonlinear function

MILTON FELSTEIN
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Washington, D. C.

AMONG the best-known methods of interpolating to unequal intervals are those of Aitken and Lagrange.[1] These methods, although they differ in approach, involve similar combinations of the given values.

Aitken's method consists of a sequence of linear interpolations (or extrapolations) starting with an approximate interpolation and going on to further refinement of the required value by the use of previously interpolated values. Lagrange's method involves the direct evaluation, at the intermediate x-value, of the n-degree polynomial representing a curve passing through the given tabular points $(n + 1)$.

The accompanying chart, Fig. 1, presents a self-checking computation form that leads to the desired interpolated value by a combination of both methods. Use of this chart provides a check on the accuracy of the calculated value. A representative example is shown. The procedure followed in the solution of this problem can be used, with the proper values, to solve any similar problem.

Example: From the tabulated values of x (radians), line 0, and of sin x, line 2, calculate sin 0.810359. Note that the values of x are in ascending order.

The procedure for Aitken's method, (solid blocks in chart, Fig. 1) is:

1. Enter the intermediate x-value, 0.810359, in 8-G (line 8, column G).

2. Calculate the quantities in lines 8 through 13 as indicated in the chart, Fig. 1.

3. Subtract the product of (2-B) (8-A) from (2-A) (8-B). This is simply a determinant. Divide the result by 9-B and enter the answer in 3-B. Similarly, subtract (2-C) (8-A) from (2-A) (8-C), divide by 9-C, and enter the result in 3-C. Perform this operation for the remaining columns and enter the calculated values in 3-D, 3- E, and 3-F.

4. Calculate the determinants based on line 3. Subtract (3-C) (8-B) from (3-B) (8-C), divide by 10-C and enter in 4-C. Perform this operation for the other columns, and enter the calculated values in 4-D, 4-E, and 4-F.

5. Calculate the same values for lines 4, 5, 6, and 7. The result obtained in 7-F is the required interpolated value.

It sometimes happens that intermediate results, such as 6-E and 6-F, are identical. In this case, further refinement of the value is unnecessary.

The procedure for Lagrange's method (dotted blocks in Fig. 1) is:

1. Calculate the D-values in column G. These are the products of the values in lines 9 through 13. Terms to be multiplied are indicated by the arrows in the chart. Thus, D_A = (9-B) (9-C) (9-D) (9-E) (9-F), D_B = (9-B) (10-C) (10-D) (10-E) (10-F), D_C = (9-C)(10-C)(11-D)(11-E)(11-F), etc. Signs of these values depend on the number of terms in the line adjacent to the D-value being calculated. If the number of terms is even, the sign is positive; if

[1]References are tabulated at end of article.

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the number is odd, the sign is negative. For example, for the five values necessary to obtain D_B, the four values in line 10 indicate a plus sign.

2. Determine the N-values in line 1. These are the products of the terms in line 8, in each case omitting the term in line 8 which is in the same column as the N-value being calculated. For example, $N_A = (8\text{-}B)(8\text{-}C)(8\text{-}D)(8\text{-}E)(8\text{-}F)$; $N_B = (8\text{-}A)(8\text{-}C)(8\text{-}D)(8\text{-}E)(8\text{-}F)$. If the number of terms is even, the signs of the N-values are determined algebraically from the component terms. If it is odd, as in this case, the sign is opposite to the algebraic sign.

3. Calculate line 15 from the formula shown. Add the values algebraically and enter in Y_L. This value should be identical to that in Y_A.

In case of a discrepancy between Y_L and Y_A, the results from the Lagrangian method may be easily checked.[2] N/D-values in the columns which bracket the interpolant, in this case C and D, should always be positive, the signs then alternating as they move away from the interpolant. In addition, the sum of the N/D-values should be equal to 1.

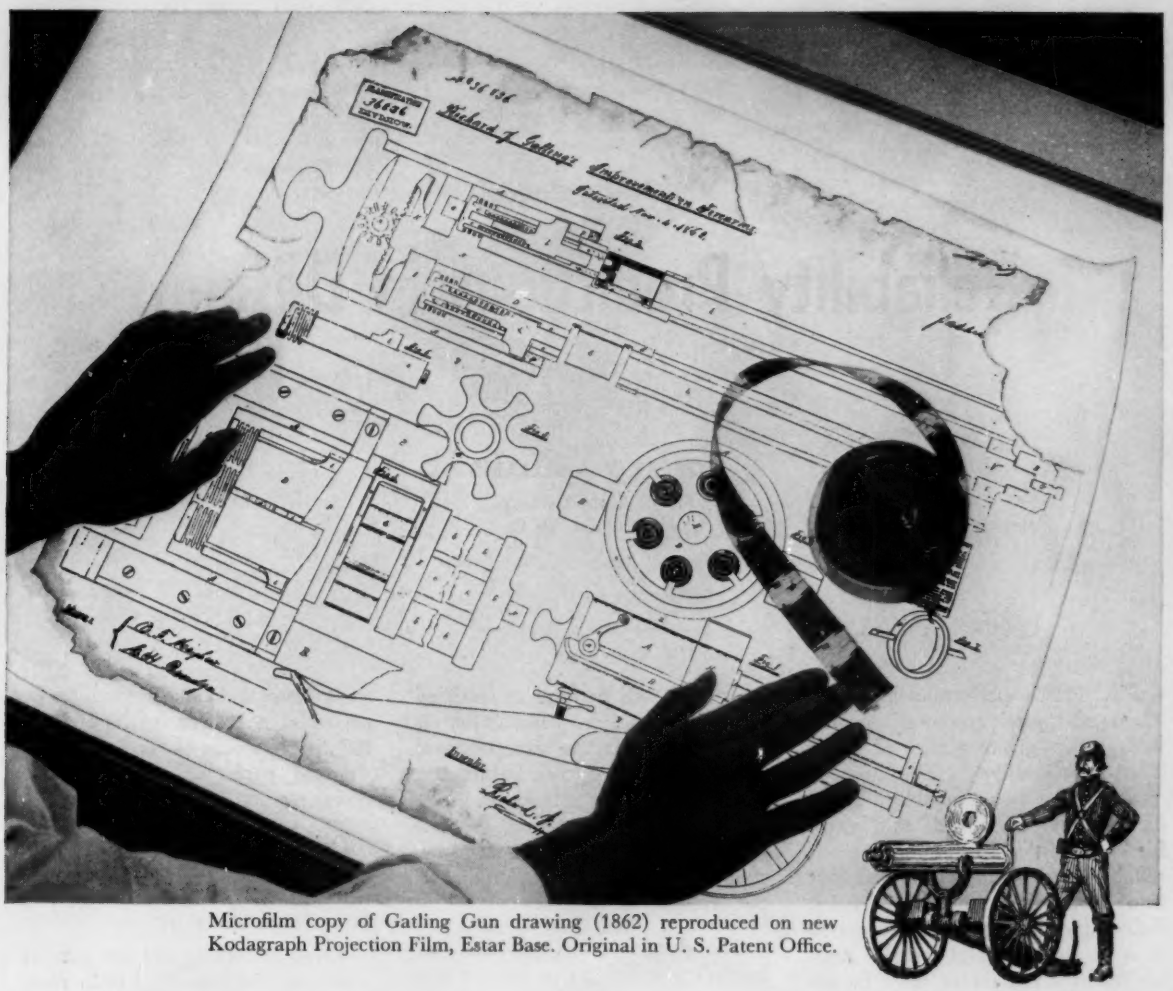
In the preceding method, all computations should be carried out so that they may be rounded off to one more place than the number required in the final answer. The form shown in Fig. 1 provides for a maximum of six tabular values. It can be extended, of course, to include any desired number of values.

REFERENCES

1. W. E. Milne—*Numerical Calculus*, Princeton University Press, 1949, pp. 69-72 and 83-85.
2. R. A. Buckingham—*Numerical Methods*, Sir Isaac Pitman & Sons Ltd., 1957, pp. 72-73.

	A	B	C	D	E	F	G
0	x_0 (+) 0.600	x_1 (+) 0.650	x_2 (+) 0.750	x_3 (+) 0.900	x_4 (+) 1.100	x_5 (+) 1.380	
1	N_A (−) −0.1431540 ×10⁻³	N_B (−) −0.1877894 ×10⁻³	N_C (−) −0.4989102 ×10⁻³	N_D (+) 0.3359369 ×10⁻³	N_E (+) 0.1039697 ×10⁻³	N_F (+) 0.5286439 ×10⁻⁴	
2	y_0 (+) 0.564642	y_1 (+) 0.605186	y_2 (+) 0.681639	y_3 (+) 0.783327	y_4 (+) 0.891207	y_5 (+) 0.981854	
3		(+) 0.7352179	(+) 0.7287178	(+) 0.7179832	(+) 0.7020338	(+) 0.6771603	
4			(+) 0.7247944	(+) 0.7241629	(+) 0.7233926	(+) 0.7224644	
5				(+) 0.7245403	(+) 0.7245527	(+) 0.7245712	
6					(+) 0.7245347	(+) 0.7245345	
7						(+) 0.7245349	y_A (+) 0.724535
8	$x_0 - x$ (−) −0.210359	$x_1 - x$ (−) −0.160359	$x_2 - x$ (−) −0.060359	$x_3 - x$ (+) 0.089641	$x_4 - x$ (+) 0.289641	$x_5 - x$ (+) 0.569641	x (+) 0.810359
9	→	$x_1 - x_0$ (+) 0.050	$x_2 - x_0$ (+) 0.150	$x_3 - x_0$ (+) 0.300	$x_4 - x_0$ (+) 0.500	$x_5 - x_0$ (+) 0.780	D_A (−)(+) -0.877500×10^{-3}
10		→	$x_2 - x_1$ (+) 0.100	$x_3 - x_1$ (+) 0.250	$x_4 - x_1$ (+) 0.450	$x_5 - x_1$ (+) 0.730	D_B (+)(−) 0.4106250×10^{-3}
11			→	$x_3 - x_2$ (+) 0.150	$x_4 - x_2$ (+) 0.350	$x_5 - x_2$ (+) 0.630	D_C (−)(+) $-0.4961250 \times 10^{-3}$
12				→	$x_4 - x_3$ (+) 0.200	$x_5 - x_3$ (+) 0.480	D_D (+)(−) 0.1080000×10^{-2}
13					→	$x_5 - x_4$ (+) 0.280	D_E (−)(+) $-0.4410000 \times 10^{-2}$
14	$\frac{N_y}{D}$					→	D_F (+) 0.4821224×10^{-1}
15	(+) 0.0921148	(−) −0.2767672	(+) 0.6854657	(+) 0.2436560	(−) −0.0210109	(+) 0.0010766	y_L (+) 0.724535

Fig. 1—Self-checking chart for interpolating to unequal intervals. The chart combines two methods of interpolation, those of Lagrange and Aitken.



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Reliability Predictions in Design

ROBERT T. WILLIAMS
ARINC Research Corp.
Washington, D. C.

SPECIFIED performance under stated environmental conditions for a given period of time. This is reliability. The unit of measurement is a probability statement, often expressed as "mean life." Statistical techniques permit reliability to be measured and put into meaningful numerical form. Reliability can be explicitly stated as a requirement and tested. Reliability as a parameter must be designed into new systems. The purpose of this paper is to discuss the use of predictions as a tool to aid in designing reliability into complex systems.

Pro and Con

Since reliability is an estimation process, reliability predictions are not readily accepted as a valuable design tool. Here is a critique of some of the common reasons or statements advanced for discounting predictions.

We do not know if the system will even do the job we hope it will, so how can you tell me how reliably it will do it?

The worth of a system is expressed by its effectiveness to do the job for which it was designed. Three factors contribute directly to a system's effectiveness, only one of which is reliability. The reliability contribution is a probability that the system will perform as specified for a given time. Reliability is based on the failure experience of parts reflecting system failures on systems in similar situations. Prediction does not attempt to state how accurate or how adequate design will be from the standpoint of performance or accuracy.

The design is not finalized—we haven't selected parts yet, so any predictions you make won't be meaningful.

This statement does not have a good basis. Numerous voltage, current, and other measurements are made before the design is finalized. Predictions during the design process will always be behind if for no other reason than the design changes resulting from predictions. As bread-board testing becomes more complete, the inputs of stress and application become better known and the subsequent predictions more accurate.

I am using new parts. Data you have are on parts three and four years old.

This statement is a valid argument. There is no doubt that graduation improvement in parts is a continuing process. As a consequence of this improvement, predictions may be slightly pessimistic. Although it is true that performance data lag, the lag is small, and the information on what can be expected of a system in the light of failure experience of three and four-year-old parts will soon be most revealing.

Once the system is packaged, the environments will change. We always have a rash of trouble—how can you predict this?

Areas of trouble are not predictable individually. A certain number of problems will show up in a complicated system. A designer realizes that environment is a major factor in system reliability. Thus, he will design to minimize adverse effects if he knows how to make trade-offs between them and other design considerations. Here the reliability specialist can help.

The data we have are all from one category of systems. My new product's environment is much better; therefore, the data are not applicable.

It is often true that the best available data are not from a system that is exactly like the one being predicted, nor are the environments likely to be identical. However, most good data sources provide for judgment or "k" factors to account in general for the differences. Prediction techniques are estimation processes and, as such, admit to errors in sampling and translation. Prediction processes estimate *mean*

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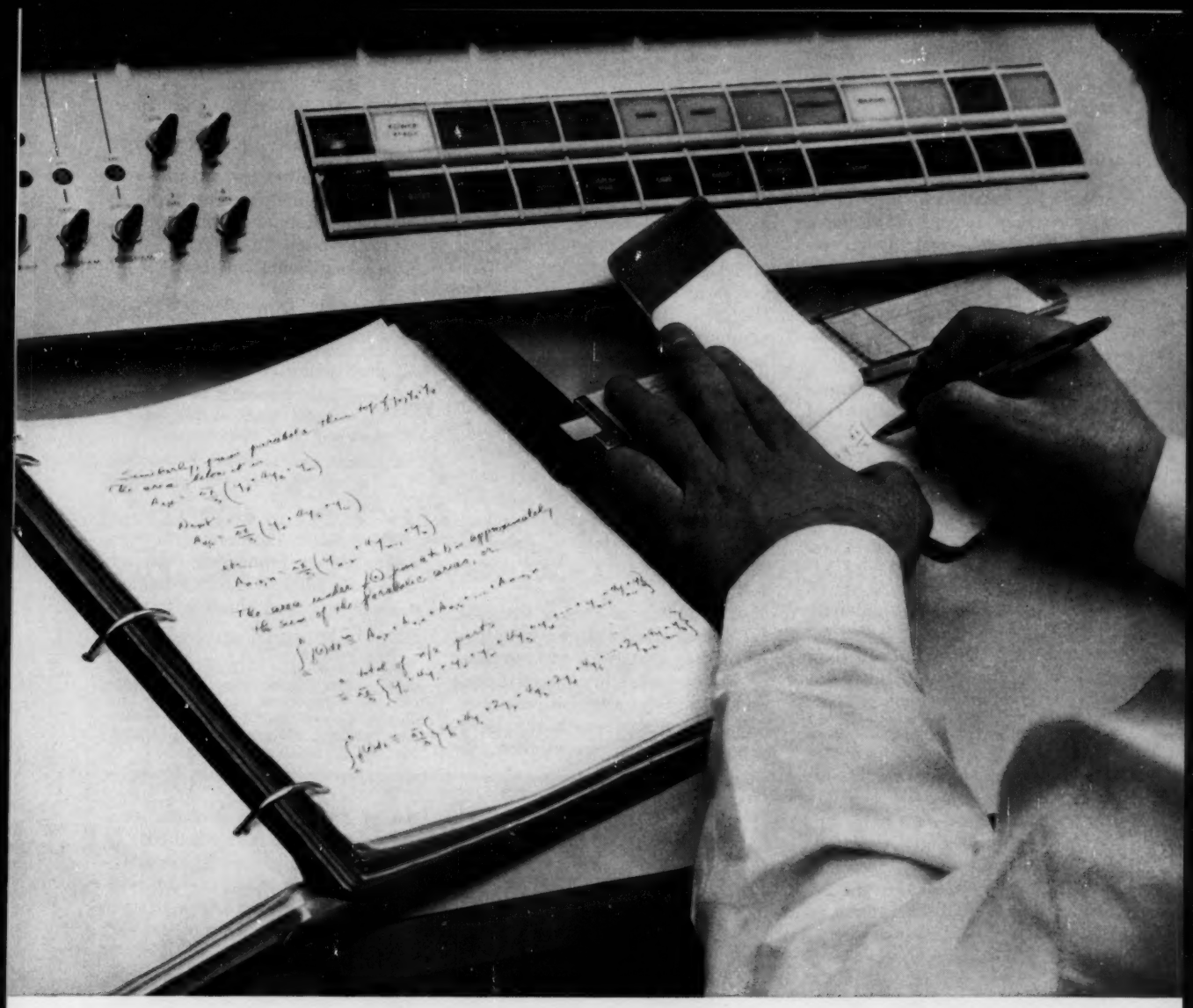

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values, as in statistics.

We have seen much better (lower) rates than these. We've got a good design program, design review, check-out and test program. We're going to eliminate all responsibility problems. Your figures are so pessimistic they are meaningless.

Good check-out test programs and design review are a part of every sincere design effort. It is better to use this effort, and especially the test program, to refute and disprove the predictions, and thus verify that an improvement has been made, than to scoff at predictions.

What am I going to do differently if your prediction shows I've not met my goal? Until you can show me how to change, I'm not going to waste my time predicting.

The process which is gone through in arriving at a prediction often provide valuable insight into tolerance problems, misapplications, potential over-stressing, and severe environmental situations. Prediction of part data, calculation of pertinent stresses, and the adjustment factors all work as a design review oriented toward reliability. Most of the valuable changes result during the prediction process.

Benefits

It is better to know the practical reliability limitations on a design in advance than to learn them from unsatisfactory field experience. It is now appropriate to review some of the ways in which prediction can help in the design effort.

1. Determination of Design Feasibility: As a design progresses, the feasibility of the initial design can be gaged by comparison of the predicted capability with requirement and the initial predictions. Results of these comparisons can lead to initial acceptance of the design philosophy with more confidence, or to a change in the program concepts, or to initiation of redesign before it becomes too costly, or to incorporation of redundancy, or to part-and-component development.

2. Equipment Redesign or Reassessment: Prediction processes will point out those units in need of redesign and provide a basis of comparison for the effectiveness of the redesign. Two courses are possible if an equipment does not meet its initial reliability allocation. The first is redesign. The second is reallocation of the over-all system requirement to permit the equipment to continue with a lower reliability.

3. Establishment of Maintenance Concepts: On equipments capable of being maintained, the knowledge of expected failure habits can be of great assistance in establishing test points and in the design of packaging for ease in maintenance and accessibility.

4. Evolution of Design Progress: Initial calculation of reliability can be used as a basis for measurement of design reliability improvement and maturity as a system progresses. This is consistent with the forthcoming military specification requirements for continuance monitoring of reliability.

5. Data Limitations: In the process of determining the early design predictions, limitations in available data are often uncovered. The more likely limitations are:

a. Inadequate specification information on parts.
b. Insufficient knowledge of tolerance relationships.
c. Insufficient knowledge of effects of the complex inner actions between parts and their environment.
d. Lack of basic stress-and-use information on relatively new or untried parts.

Plans can be formulated to overcome these limitations through work with vendors and procurement departments, and through test design.

Paper "The Value of Design Prediction," presented in Session 8A of the Seventh National Symposium on Reliability and Quality Control in Electronics, Philadelphia, January, 1961, symposium Proceedings, pp. 375 to 379.

electrical

Standard Specifications for Linear Automatic Controls

J. E. Gibson, Z. V. Rekasius, E. S. McVey, R. Sridhar, and C. D. Leedham, Purdue University

Considerations for standardization of performance specifications in the field of automatic controls. The specifications herein discussed fall into three groups: Frequency domain, time domain, and generalized performance indices.

AIEE Paper No. 61-78, "A Set of Standard Specifications for Linear Automatic Control Systems," presented at the AIEE Winter General Meeting, New York, January-February, 1961, 23 pp.

First-Stage Damping in An Electrohydraulic Servo Valve

Thomas W. Thompson and Paul F. Hayner, Sanders Associates Inc.

Schematic and block diagrams for a servo valve. It is assumed that the block diagram represents a linear system. The blocks are manipulated to produce a simpler block diagram and to illustrate points of interest. Particular attention is directed to the problem of damping the first stage of the servo valve and practical methods of damping are discussed. One method of damping makes use of pressure of feedback on the first stage flapper due to the mass of the output spool.

It is concluded that pressure feedback applied to the flapper of a two-stage servo valve increases the damping on the first stage. This damping can be raised to a significant level by allowing more than normal leakage in the first stage. Therefore, this method of damping can be applied where steady-state oil flow is not tightly restricted.

AIEE Paper No. CP 61-154, "Damping the First Stage of a Two-Stage Electrohydraulic Servo Valve," presented at the AIEE Winter General Meeting, New York, January-February, 1961, 7 pp.

Electronic Components for Use at High Temperatures

L. F. Kilham, Raytheon Co.

Design of electronic components for operation at 500 C. Presently, there appear to be two distinct and diametrically opposite component design approaches to extreme high-temperature environments. The first approach is the selection of

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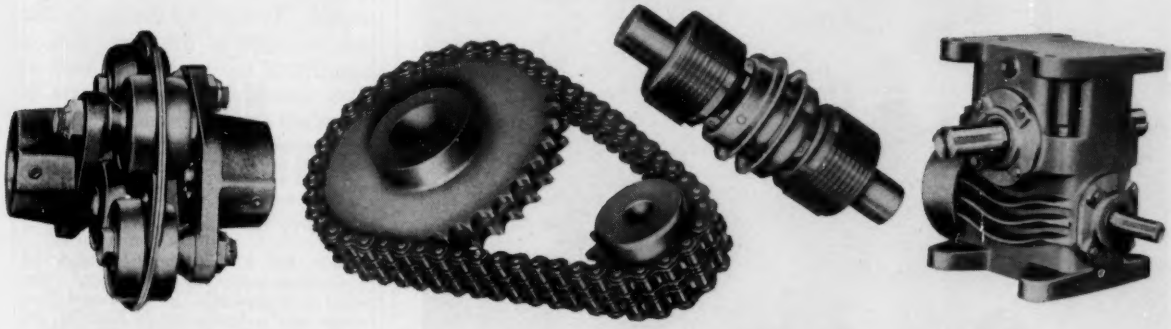

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suitable temperature-resistant materials and the application of special techniques to design components to withstand the severe extremes of temperature. The other approach is the simple expedient of operating conventional components in a cooled atmosphere. The latter approach may inflict a penalty of an overall increase in size and weight.

Present-day electronic equipment consists of inductors, transformers, capacitors, tubes, and other component parts, and they in turn may be further reduced to four broad material categories: Insulating materials, structural materials, conducting materials, and magnetic materials.

Thermal endurance of organic insulation has been the determining element regarding the upper temperature limit of component operation. Therefore, at high operating temperatures it becomes necessary to find inorganic substitutes.

A new type of flexible insulation has been developed. This material is based on bentonite clay film studies. To improve the tensile and tear strength of this clay film, a quantity of inorganic fiber such as glass, quartz, aluminum silicate or potassium titanate is added. A thin coating of silicon resin gives added strength. Films of 0.0005 in., with breakdown voltage of 1500 volts per mil, have been made.

Paper No. 1, "Component Design for High Temperature Environment," presented in Session 5C, Third National Conference on the Application of Electrical Insulation, Chicago, December, 1960, Conference preprints pp. 160 to 162.

hydraulic

Use of Derivative Pressure Feedback in High Performance Hydraulic Servomechanisms

T. R. Welch, Infrared Laboratory, Aerospace Engineering Div., Hughes Aircraft Co.

A hybrid method of compensation whereby pressure feedback occurs only in the region of resonant frequency, effectively preserving the natural output disturbance discrimination characteristics at lower frequencies. The pressure drop across positive displacement type hydraulic actuators is a good measure of

acceleration. Therefore, the technique involves feeding back this load differential pressure, sensed by electromechanical transducers, through a simple RC high pass (derivative filter. The effectiveness of the damping is determined by the filter time constant and loop gain. Experimental results verify linear predictions of the possibility of extending the closed loop bandwidth beyond the uncompensated resonant frequency.

ASME Paper No. 61-Av-4, "The Use of Derivative Pressure Feedback in High-Performance Hydraulic Servomechanisms," presented at the Aviation Conference, Los Angeles, March, 1961, 7 pp.

materials

Comparison of Blown and Chill-Cast Plastic Film

G. Denis Murphy, Spencer Chemical Co.

How chill-cast polyethylene film differs from blown film. Chill-cast film can be produced with optical characteristics superior to those obtainable from blown film; however, the resultant film will be weaker. If processing conditions are suitably altered during chill casting, then strength may be upgraded at the expense of less gloss and higher haze. These effects are no less important in the processing of blown film as changes in both cooling rate and blow-up ratio will alter both film appearance and film strength.

SPE Paper No. 18-3, "A Comparison of Blown and Chill-Cast Polyethylene Film," presented at the 17th Annual Technical Conference of the SPE, Washington, D. C., January, 1961, 6 pp.

processes

Forming Processes for High Temperature Metals

I. J. Wilson, North American Aviation Inc.

Methods and techniques for forming parts from the sheet materials which lend themselves to elevated-temperature use.

Conventional sheet-metal structure has undergone a change in the interest of saving weight. Designs requiring fewer pieces result in larger and more complex shapes. Forming is further complicated by

such material characteristics as low ductility, high spring-back, transformation growth, and warpage during heat-treatment. The use of very thin sheet gages compounds the difficulty.

This presentation is divided into four parts according to the material types: Precipitation-hardening stainless steel, H-11 type tool sheet, heat-treatable titanium alloys, and nickel-base alloys.

ASME Paper No. 61-AV-6, "Forming of Hi-Temperature Metals," presented at the Aviation Conference, Los Angeles, March, 1961, 8 *pp.*

Preparation of Thin Ferrite Films

Henry P. LeMaire and William J. Croft, Radio Corp. of America, Semiconductor and Materials Div., Radio Corp. of America

Preparation by two methods, both involving a spray technique using hot suspensions of hydroxides directed onto a heated substrate. The ferrite films are formed essentially through a coprecipitation mechanism. Various compositions have been attained: Magnetite, nickel ferfite, a magnetite-zinc ferrite series, and other mixed ferrites.

Hysteresis loops indicate a high squareness ratio. The films as prepared are magnetically isotopic.

Film thicknesses can be varied from a few hundred angstroms to about 1 micron. Coercive force measurements are related to thickness in a set of nickel ferrite films and to composition variations in a series of films of differing composition in magnetite-zinc ferrite series.

Paper No. 15, "Ferrite Thin Films," presented at the Sixth Annual Conference on Magnetism and Magnetic Materials, New York, November, 1960.

mechanical

Lightweight Thermal Insulation By Transpiration Cooling

John G. Krisilas, specialist, Thermodynamics, and John E. Boberg, research engineer, Lockheed Aircraft Corp.

A composite thermal barrier suitable for extreme environments. A layer of porous insulation (consisting of conventional Fiberglas insulation batts) is located between

the exterior skin and the interior trim, forming an air passage on either side. Air is directed into the inner air passage and passed through the porous insulation in an outward direction to counteract the inward flow of heat.

This is a specialized application of the familiar method of transpiration cooling except that the cooling air is collected after passing through the insulation rather than continuing directly through the outer skin to the boundary layer. After passing through the porous insulation and being collected, the air may either be exhausted at a temperature approximately that of the exterior skin or it may be cooled by refrigeration equipment, and recirculated.

ASME Paper No. 61-AV-1, "Lightweight Thermal Insulation by Transpiration Cooling," presented at the Aviation Conference, Los Angeles, March, 1961, 8 pp.

techniques

Data Presentation for Cushioning Materials

W. G. Soper and R. C. Dove, University of New Mexico

Dimensional aspect of cushioning problems and methods for presenting experimental data. Conclusions are valid for any cushioning material, regardless of the complexity of its stress law.

This paper consists of three parts. The first discusses the scaling law for a general cushioned system. The analysis is restricted to impulse loading. It is shown that the important parameters of acceleration and displacement can each be completely expressed by one family of curves.

The second part introduces a simpler scaling law which applies when the system satisfies certain conditions relating to the geometry of the system and the nature of the material. This law allows material thickness to be varied independent of other material dimensions. The result is a method for applying experimental data to a wider range of physical problems than covered by the treatment of the first section.

The third section presents data on a variety of materials in the higher energy ranges. Included are some foamed plastics, rubber compounds,

metal honeycombs, and foamed metals.

SPE Paper No. 27-4, "Data Presentation for Cushioning Materials," presented at the 17th Annual Technical Conference of the SPE, Washington, D. C., January, 1961, 6 pp.

Rate-Diagram Analysis Of An On-Off Control System

H. Patapoff, Space Technology Laboratories Inc.

Development of a technique in which the performance of a class of on-off control systems can be analyzed by means of a "rate diagram." Such a diagram is a plot of the controlled element output rate at control removal versus the rate at control application. Information regarding system stability, transient response, limit cycles, and duty cycles can readily be obtained directly from the rate diagram.

This method can be used effectively as a design tool in optimizing systems to meet specified performance requirements. As filter parameters or controller characteristics are varied, the designer can see the resulting change in the rate diagram.

An extension to the rate diagram can be made to include cases in which a disturbance acceleration is present, and in which the controlled element has a general second-order transfer function. This requires a modification in the interpretation of the rate diagram.

AIEE Paper No. CP 61-81, "Rate Diagram Method of Analysis of an On-Off Control System," presented at the AIEE Winter General Meeting, New York, January-February, 1961, 7 pp.

Response of Linear Systems Under Time-Dependent Multidimensional Loadings

F. P. Beer, professor, Dept. of Mechanics, Lehigh University

The concept of frequency response —long used by communication engineers to predict the response of a linear system to a periodic, nonperiodic, or random input—extended to the general case of a linear mechanical system subjected to time-dependent, multidimensional loading. Various possible methods for

determining the transfer function of a given system are examined. One method is given special attention.

ASME Paper No. 60-WA-106, "On the Response of Linear Systems to Time-Dependent, Multidimensional Loadings," presented at the Winter Annual Meeting, New York, November-December, 1960, 7 pp.

IC Engine Cycle Analysis From Combustion Equations

Leo T. Brinson, Jr., assistant chief engineer, Nordberg Mfg. Co.

A method of evaluating the scavenging efficiency of a two-stroke cycle diesel engine based solely on data obtained from the particular engine under tests. Incidental data from a single-cylinder engine is included for the purpose of demonstrating the validity of the procedure, and the quality of results which can be achieved. Comparison of test-engine thermal efficiency with the theoretical thermal efficiency shows good correlation through the use of a "diagram factor" which is substantially constant for a given engine.

ASME Paper No. 61-OGP-2, "Cycle Analysis from Combustion Equations," presented at the Oil and Gas Power Conference, New Orleans, April, 1961, 4 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

Third Annual Conference on the Application of Electrical Insulation, sponsored by the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., and the National Electrical Manufacturers Association.

Sixth Annual Conference on Magnetism and Magnetic Materials, sponsored by the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., and the American Institute of Physics, 335 East 45th St., New York 17, N. Y.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 50 cents to members, one dollar to nonmembers.

SPE—Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn., papers 25 cents to members, 40 cents to nonmembers.

Seventh National Symposium on Reliability and Quality Control, Proceedings, 538 pp., available from Editorial Dept., Institute of Radio Engineers, 1 East 79th St., New York 21, N. Y., five dollars per copy.

Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Silicone Data

Comprehensive booklet on silicones, graphically illustrated with photographs, charts, and graphs, gives details about what silicones are, describes their uses for consumer and industrial products, and suggests ways in which they can be adapted to new applications. Series of charts covers properties and features of silicone fluids, resins, rubber compounds, water repellents, antifoams and emulsions, and lists adaptability for use by various industries. 16 pages. Silicones Div., Union Carbide Corp., 270 Park Ave., New York 17, N. Y.

Circle 501 on Page 19

Adjustable-Speed Drives

Catalog G-100 covers complete line of Vari-Speed Motodrives, ¼ through 40 hp. Data include full rating tables, with new additional output speeds. Dimension diagrams, photographs, and charts for over 100 different assemblies, higher overhung load, and new controls, are also contained. Section on engineering information is also included. 88 pages. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.

Circle 502 on Page 19

Stock Transformers

Catalog CS-101 lists almost 900 stock transformers for industrial applications. It is cross-indexed for quick location of the desired listings. Each transformer is fully described and illustrated, and detailed dimensional information as well as complete electrical specifications are given for all units. Performance curves are included where applicable. 34 pages. Chicago Standard Transformer Corp., 3501 W. Addison St., Chicago 18, Ill.

Circle 503 on Page 19

Polyester Resins

"Laminac Polyester Resins Selector" describes the characteristics, fabricating procedures, and end uses of 24 standard Laminac formulations. They are grouped by performance—general purpose, room temperature lay-up, resilience, hot strength, chemical-resistance, electrical grade. 12 pages. Plastics & Resins Div., American Cyanamid Co., Wallingford, Conn.

Circle 504 on Page 19

Industrial Ceramics

Complete line of industrial ceramics products is covered in new catalog. It includes photographs, descriptive material, sizes on beads, tubing, and rods, swageable thermocouple tubing, end seals, castables, laboratory ceramics, and special shapes. It also gives technical data on materials, electrical and mechanical properties, design recommendations, and summary of facilities. 20 pages. Saxonburg Ceramics Inc., Saxonburg, Pa.

Circle 505 on Page 19

Metalized Mylar Capacitors

Form 795 describes an expanded line of miniature, hermetically sealed, metalized Mylar capacitors suitable for miniaturized applications such as transistor circuitry or printed circuits. It includes engineering data, descriptions, and dimensions to cover three series of Mylar wrap epoxy end-seal types and two series of Mylar units in ceramic tubes. 4 pages. Potter Co., 1950 Sheridan Rd., North Chicago, Ill.

Circle 506 on Page 19

Worm-Gear Motors

Technical data, illustrations, and descriptions of new right-angle worm-gear motors are included in Bulletin F-1971. Ratings and dimensional data for U. S. Syncrogear motors are given both for single-reduction and double-reduction types. Brochure shows a number of specialized models, and illustrates optional mounting and assembly positions. Large cut-away photograph is used to point out important features. 6 pages. U. S. Electrical Motors Inc., P. O. Box 2058 Terminal Annex, Los Angeles 54, Calif.

Circle 507 on Page 19

Laminated Plastics

Basic application information and engineering data on laminated plastics and vulcanized fiber are given in 1961 condensed catalog. Data are provided to aid engineers in selecting and applying basic materials for electrical, electronic, and mechanical components. General and engineering data for 21 common grades of laminated plastics are listed. 8 pages. Taylor Fibre Co., Norristown, Pa.

Circle 508 on Page 19

Piezoelectric Devices

Illustrated booklet on the application of piezoelectric devices highlights new developments in high-power handling abilities of the materials. Designed to show the principal existing and potential uses of piezoelectricity, booklet outlines and compares the performance characteristics of all major piezoelectric substances. Text and tables cover piezoelectricity as applied to convert mechanical energy to electrical energy, and the reverse. Electromechanical properties and useful service temperature range of piezoelectric elements are also included. 16 pages. Clevite Electronic Components, Bedford, Ohio.

Circle 509 on Page 19

Miniature Electric Eyes

Bulletin 611 covers all phases of electric-eye applications in automation. Included are many illustrations and schematics showing diversified photoelectric systems ranging from miniaturized light sources and photo units to time delays. Detailed descriptions are given for electronic controls and time delays. 22 pages. Photomation Inc., 96 S. Washington Ave., Bergenfield, N. J.

Circle 510 on Page 19

Ball Bearings

Catalog 4E gives dimensional data on inch, metric, pivot, and special series of RMB miniature ball bearings, using pictures, dimensional drawings, and tables. Bulletin lists the part numbers of inch-series bearings produced by other manufacturers which are interchangeable with RMB bearings. 4 pages. Landis & Gyr Inc., 45 W. 45th St., New York 36, N. Y.

Circle 511 on Page 19

Valve Selector Chart

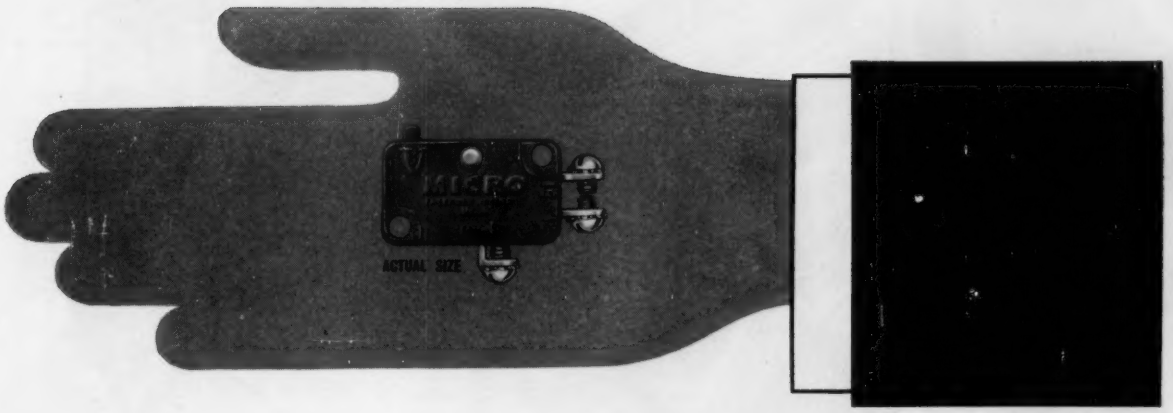
Bulletin SL-1 contains necessary information for quick, accurate selection of the proper solenoid valve for particular applications. Specific data regarding size, pressure, temperature, coil type, special features, and assemblies are condensed to aid proper selection. Table of Cv flow factors is used for quick and accurate sizing of valves. 4 pages. J. D. Gould Co., 4707 Massachusetts Ave., Indianapolis 18, Ind.

Circle 512 on Page 19

Aluminum Selection

Aluminum-alloy sheet, coil, and blank data needed most often are summarized in three-way Design Data File. Principal selector chart outlines detailed data on ten most used alloys, including applications, uses, strengths, thermal and electrical conductivity, density, specific gravity, melting range, and manufacturing limits. Basic manufacturing data are augmented with reference charts on weights, tolerances, fabrication characteristics, available finishes, hardening properties, and embossing designations. 6 pages. Fairmont Aluminum Co., Fairmont, W. Va.

Circle 513 on Page 19



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(With quick-connect terminals)

Single-pole double-throw

Single-pole double-throw
(Extra-long life, mushroom head plunger)

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...WITH NEW, HIGHER CAPACITIES! This versatile series of basic switches combines miniature size with new, higher electrical capacities. Switch cases and plungers are available in different plastic materials to meet varying requirements. Special high-temperature versions with synthetic mica cases withstand temperatures up to 600° F. Contact arrangements include double-throw, normally-open or normally-closed, with a choice of terminals. Models are available which conform to applicable requirements of Military Specification MIL-S-6743. "V3" Series basic switches are especially adaptable to multiple cam-operated gang-mounted systems and are also used as switching elements in many of our enclosures and assemblies. See the Yellow Pages for the nearby MICRO SWITCH Branch Office or write for Catalog 63.

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Circle 293 on Page 19

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Circle 294 on Page 19

FI-2654-D

Glass, Glass-Ceramics

Revised edition of "This Is Glass" reviews the history of glass and details basic types. It includes a section on Pyroceram, and a two-page chart giving properties of selected glasses and glass-ceramics. Preview of the future of glass and glass-ceramics describes the extensive research being done with these basic engineering materials. 68 pages. Corning Glass Works, Corning, N. Y.

Circle 514 on Page 19

Servo Motors

Bulletin MO-3.7A describes two-phase, four-pole reversible induction motors, designated R-24. Bulletin contains three sets of speed-torque curves. Additional information such as starting voltage, stall torque, rotor inertia, acceleration at stall, and reversing time, are summarized in a single comprehensive chart. Gear motor torque tables, electrical connection diagrams, and delivery data are also included. 14 pages. Holtzer-Cabot Motor Div., National Pneumatic Co. Inc., 125 Amory St., Boston 19, Mass.

Circle 515 on Page 19

Color-Measurement Equipment

Booklets describing the Green-Bartlett technique of high-speed, fully automatic color measurement are now available. Described equipment is well suited to feedback process control, continuous color inspection, and high-speed color sorting and grading. Information on this equipment is provided in two brochures, one on general product-sorting capabilities and the other describing technical details and applications of the colorimeter. 4 pages each. Colorimetry Div., Allied Research Associates Inc., 43 Leon St., Boston 15, Mass.

Circle 516 on Page 19

Chain Selection

Choosing recommended chain pitch sizes for power-transmission chain is simplified by use of new quick-selection wall chart. Printed on heavy paper suitable for wall mounting or filing, chart lists design horsepower on the vertical axis and rpm speeds for the small sprocket on the horizontal axis. Location of the intersection of any two selected combinations of these factors gives recommended chain pitch size. Foote Bros. Gear & Machine Corp., 4545 S. Western Blvd., Chicago 9, Ill.

Circle 517 on Page 19

Gears and Related Parts

New folder contains photographs and engineering data on 28 types of gears and related parts, including gear heads, differentials, worms and worm wheels, special forms, clamps, and black boxes. Applications ranging from missiles, computers, airborne devices, and radar to electronics, fire control, and automation are discussed. 4 pages. Instru-Lec Corp., 520 Homestead Ave., Mount Vernon, N. Y.

Circle 518 on Page 19

Circle 295 on Page 19

HELPFUL LITERATURE

Precision Potentiometers

Short-form catalog provides detailed specifications on 1544 standard subminiature Squaretrim precision potentiometers. Included are standard units which give circuit designers wide latitude in potentiometer selection. Also described are latest rotary potentiometers. Cutaway drawings show how the V-guide eliminates backlash and resultant error, and photographs illustrate how separate potentiometers in a gangable series can be adjusted without affecting adjoining units. 6 pages. Potentiometer Div., Daystrom Inc., Archbald, Pa.

Circle 519 on Page 19

High-Strength Bolt

High bolting strength for temperature applications to 1200 F is the subject of Form 2717, which details the performance of EWB 1218 external-wrenching bolt. Complete mechanical properties are covered. Comparisons of the bolt with bolts of A-286 alloy include tabulations of minimum strength as well as a plot of stress relaxation. Literature reviews significant aspects of design and processing, and lists complete dimensional specification data. 4 pages. Box 102, Standard Pressed Steel Co., Jenkintown, Pa.

Circle 520 on Page 19

Pilot-Operated Valve

Bulletin 91043 describes Tube-O-Matic pilot-operated valve, originated to solve problems of valve wear and maintenance in controlling abrasive or corrosive fluids and gases. Bulletin uses tables and line drawings to supply descriptions, specifications, outstanding features, optional features, ordering data, and dimensions. 4 pages. Airmatic Valve Inc., 7313 Associate Ave., Cleveland 9, Ohio.

Circle 521 on Page 19

Drafting Film

New brochure describes strength, erasure, reproduction, stain, and durability characteristics of Herculene polyester-based film for general drafting-room use. Also included is a report on how the surface of the film takes pencil, type, and ink. Information is offered on the application of the film for both washable and nonwashable tracings. 8 pages. Keuffel & Esser Co., Third & Adams Streets, Hoboken, N. J.

Circle 522 on Page 19

Teflon Terminals

Press-Fit Teflon terminal catalog shows the entire line of units available. Pictures, line drawings, and tables describe subminiature stand-offs, subminiature feedthroughs, probes and plugs, miniature stand-offs, miniature feed-throughs, connectors, and test jacks. Insertion tools for installation of the units are also listed. 4 pages. Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y.

Circle 523 on Page 19

WHERE SAFETY AND RELIABILITY ARE ESSENTIAL . . .

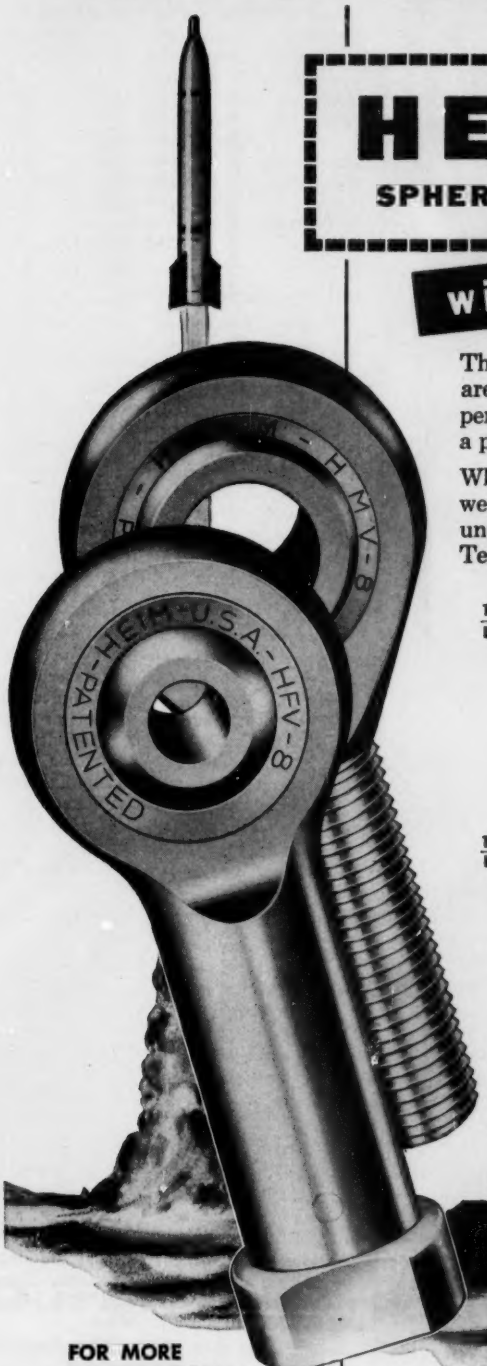
HEIM *Unibal*®

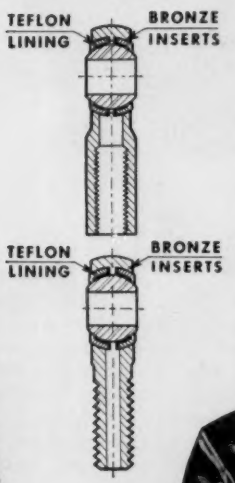
SPHERICAL BEARING ROD ENDS

with TEFLON® linings

There are conditions of operation where lubricated bearings are undesirable or incapable of operation, in extreme temperatures, corrosive or humid conditions, or where there is a possibility of lubricant failure or leakage.

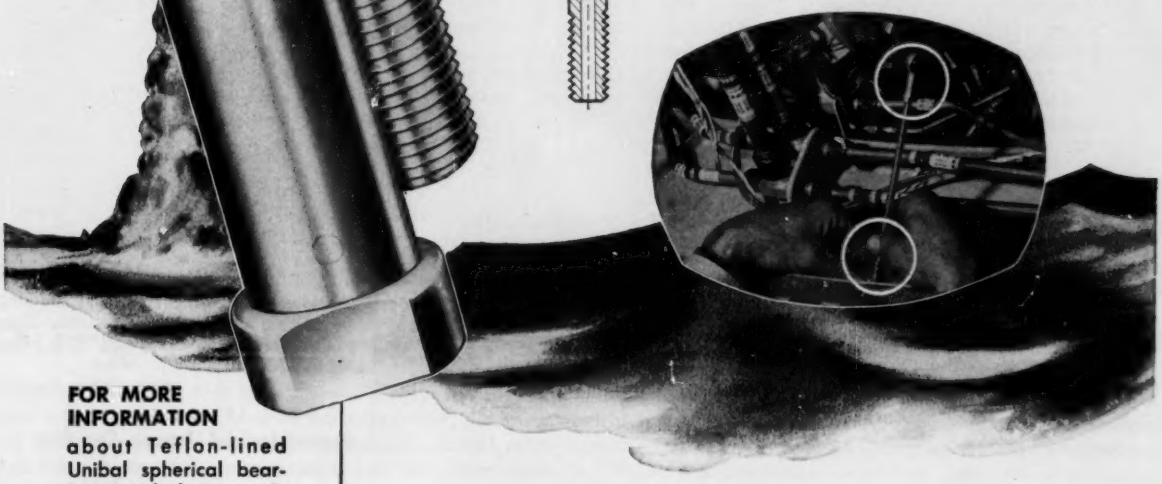
Where safety and reliability are essential; where space or weight savings are essential; where stick-slip operation is undesirable . . . special problems such as these are solved by Teflon-lined Unibal bearings.





Aircraft and missile manufacturers find that these fiber-lined Unibal bearings, especially for rod ends in rotor assemblies of helicopters, as well as in most other linkages, are outstanding in their performance and durability. They require no lubrication, and after hundreds of hours of service are still in perfect condition.

The Unibal Spherical Bearing Rod End corrects misalignment in all directions, has high load ratings, is light in weight, occupies minimum space, and is extremely simple to assemble as part of a linkage.



FOR MORE INFORMATION about Teflon-lined Unibal spherical bearings and the new 6-page bulletin including catalog listings of stock sizes available, write to:

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HELPFUL LITERATURE

Venturi Valves

New pamphlet describes venturi valves for aircraft, nuclear, industry, and marine applications. Line drawings and text show how the units operate. Included is a chart on the characteristics of venturi valves which enables the user to design his own cavitating venturi and establish approximate flow versus pressure-drop characteristics of company's venturi valves. 6 pages. Fox Valve Development Co. Inc., 36 Brentwood Drive, Verona, N. J.

Circle 524 on Page 19

In-Line Readouts

"Readout Fact Finder" shows detailed comparison of major types of in-line readouts, including electroluminescent, project-image, spherical-optic, Nixie-tube, edge-lighted, and electromechanical displays. Factors important in the selection of a display—readability, life, size, weight, and drive requirements—are compared. Many charts and tables are incorporated. 16 pages. Electronic Tube Div., Burroughs Corp., P. O. Box 1226, Plainfield, N J.

Circle 525 on Page 19

Shaft Seals

New booklet is devoted to polymer seals for reciprocating and low-speed rotary shafts operating under high-pressure liquid and gas conditions. It contains data on characteristics, design and function, detailed line drawings, design data, and size information. 6 pages. Del Mfg. Co., Div., Arrowhead & Puritas Waters Inc., 1566 E. Washington Blvd., Los Angeles 21, Calif.

Circle 526 on Page 19

Nylon Extrusions

Form 217 covers nylon tubing, pipe, rod, and strip for industrial uses. Data on sizes, weights, lengths, are included, as well as information on safe working pressures for tubing and pipe. Resin property data are also listed. 8 pages. Danielson Mfg. Co., Danielson, Conn.

Circle 527 on Page 19

Stock Sprockets

Catalog 2 provides data on roller chain sprockets in five chain sizes, with 11 to 112 teeth. Tables and line drawings are utilized to present this information. Specifications, engineering data, and ordering process are also included. 8 pages. Dayton Rogers Mfg. Co., 2824 13th Ave. South, Minneapolis 7, Minn.

Circle 528 on Page 19

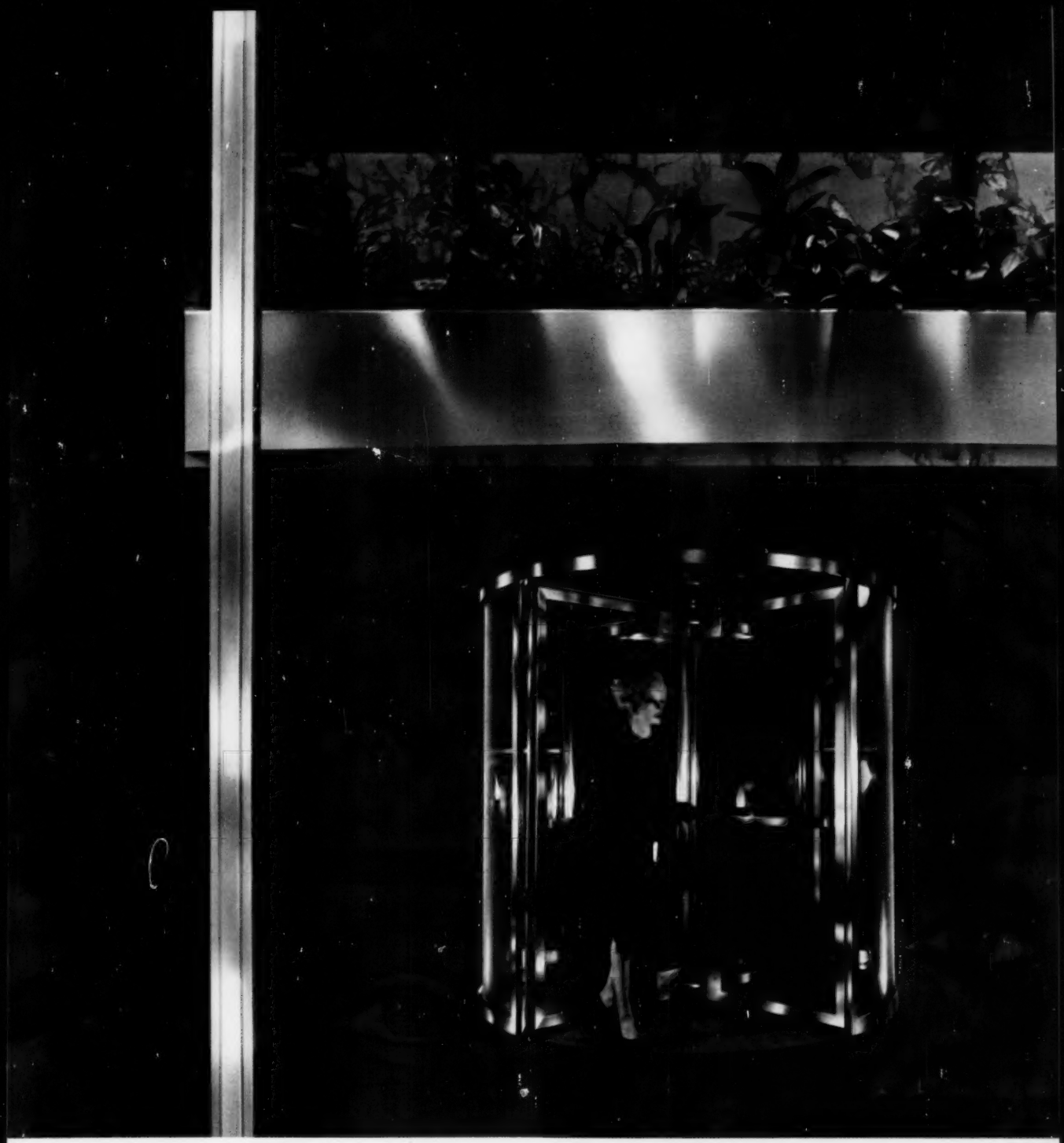
Transistorized Power Supplies

Catalog 401 provides all electrical and mechanical specifications of 53 standard transistorized power supplies. Several new models are shown, and improved specifications are listed for many standard units. 4 pages. Invar Electronics Corp., 323 W. Washington Blvd., Pasadena, Calif.

Circle 529 on Page 19

Circle 299 on Page 19

Circle 300 on Page 19→



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If this appeals to you not merely as a job but as the basis of a career, write at once (with all pertinent facts) to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

Drafting Aids

Catalog ADR-612 is a product and planning guide which describes equipment advances in the engineering field that reduce fatigue, increase individual efficiency, and save floor space. Described are various drafting tables, filing equipment, and roll tracing files. Units are pictured, and all specifications are given. 32 pages. Hamilton Mfg. Co., Two Rivers, Wis.

Circle 530 on Page 19

Terminal Insulators

Bulletin 161 shows 62 different terminal insulators carried in regular stock. Complete dimensional data are given for each insulator, as well as individual corona and flashover voltages. Bulletin includes a description of the insulator ceramic, forming techniques used, and high-temperature metalizing and brazing techniques. Data for designing special ceramic and metal assemblies are also given. 24 pages. Coors Porcelain Co., 600 Ninth St., Golden, Colo.

Circle 531 on Page 19

Liquid Spring Shocks

Handbook CH-1 features a complete line of standard liquid compressible spring Shoks for storing and absorbing from 10 to 1 million pounds of energy and 460,000 lb-ft energy absorption. Also included are springs, dashpots, time-delay Shoks, pipe systems, actuators, and accelerators. Handbook includes fully illustrated and simplified explanation of liquid compressible devices, and design data. 12 pages. Taylor Devices Inc., North Tonawanda, N. Y.

Circle 532 on Page 19

Tube Performance Calculation

Computa-Guide permits quick determination of the performance of RF doublers and triplers, as well as straight-through amplifier electron tubes. Guide eliminates much of the mathematics involved in calculating the harmonic components of a complex wave form. It facilitates designing of transmitter, telemetry, and mobile equipment, as well as ultrasonic, dielectric, and induction-heating equipment, for maximum power and efficiency. All formulas needed to derive final tube performance are incorporated in the guide, which is printed on durable, laminated plastic. Detailed instruction booklet is furnished. Write on company letterhead to Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Thermocouples, Pressure Probes

Complete specifications, details, and prices on thermocouples, pressure probes, and allied components are listed in new catalog. Units are manufactured to aircraft quality. Line drawings, tables, and photographs are used to present the data. 60 pages. Write on company letterhead to Advanced Dynamics Inc., 16321 Rockside Rd., Cleveland 37, Ohio.

Circle 302 on Page 19

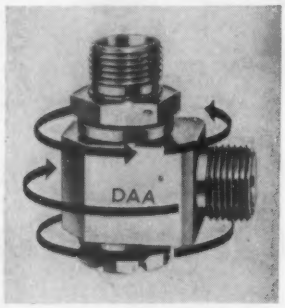
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Swivel Fittings

provide low torque ratings

Swivel units offer universal application in fluid-line systems, and can be used with almost any flow media. Compact, lightweight assemblies provide 360-deg rotation. They operate at pressures to 5000 psi. Units are pressure balanced and not subject to separation forces. The 1/4-in. tube size has a torque of less than 3/4 lb-in. at 3000 psi,



and 1-in. size has a torque less than 4 lb-in. at the same pressure. **Dumont Engineering Co.**, 1401 Freeman Ave., Long Beach, Calif.

Circle 533 on Page 19

Static Spring Seal

handles temperatures from −320 to +1500 F

New contoured static spring seal is applicable in missile, aircraft, and other liquid and gas-conduction systems where extreme temperatures and pressures are encountered. Essentially a manifold seal, it is used with a retaining flange. Seals are silver-plated Inconel-X to handle temperatures from −320 to 1500 F. Spring action of the seal is achieved from bellows configuration created by finely machined grooves in the heat-treated metal ring. Seal immediately re-

sumes original free length after release from compression. **Hydrodyne Corp.**, 7350 Coldwater Canyon Ave., North Hollywood, Calif.

Circle 534 on Page 19

Plastic-Coated Material

is pressure-sensitive

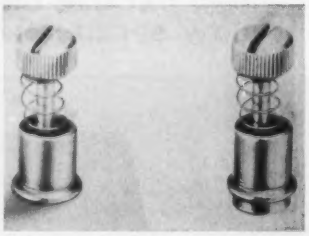
Low-cost, decorative, pressure-sensitive material, ideal for a wide range of products, is available in a variety of colors, styles, and embossing patterns. Manufactured from Pyroxylin-coated paper, it is easy to work and has minimum shrinkage. Finished parts can be printed, hot stamped, and die cut from the material. It is washable, durable, and soil and grease-resistant. **Avery Label Co.**, 117 Liberty St., New York, N. Y.

Circle 535 on Page 19

Electronic Panel Fastener

is spring-ejected type

No. 53 spring-ejected, retractable screw fastener assembly is retained in a stand-off flanged into door or chassis panel. Operating in a tapped hole or insert in the frame,



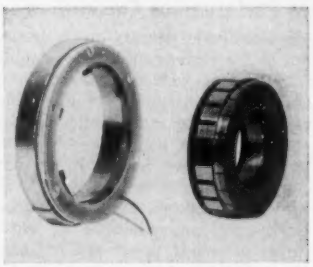
it provides zero inside projection when unfastened, providing clearance for panels to move laterally with respect to one another. Fastener assembly is available in stainless steel, bright chrome-plated, in seven thread sizes from 8-32 to 1/4-28, and three head sizes, with or without slots. **Southco Div., South Chester Corp.**, Lester, Pa.

Circle 536 on Page 19

DC Torque Motor

has completely encapsulated armature

Pancake-type Model 112 dc torque motor features high torque and small size. Armature is completely encapsulated in a glass-fiber-reinforced, high-temperature epoxy to provide maximum reliability. Motor has 2.812 in. diam by 0.625 in. length, and produces over 35 oz-in. of torque when supplied with 26 v dc. Brushless units are available



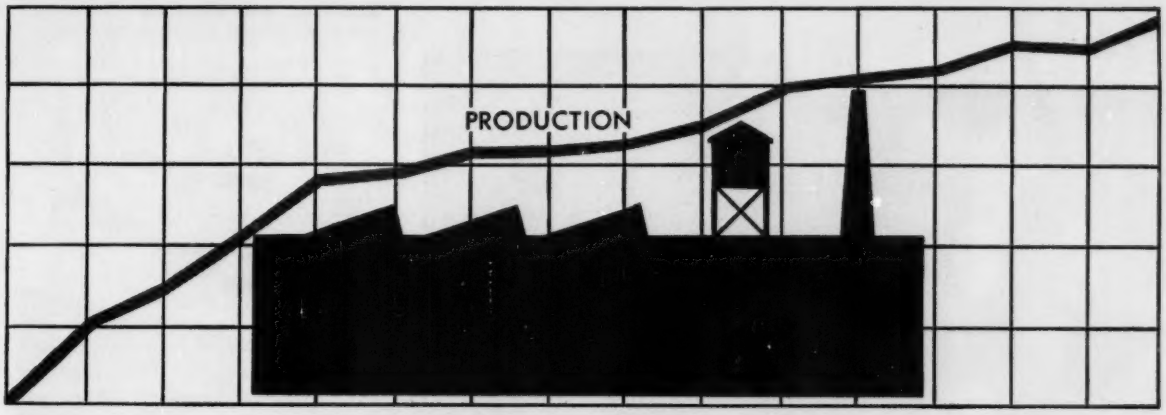
for applications involving limited angular travel. **Curvin Development Co.**, 13735 Saticoy St., Van Nuys, Calif.

Circle 537 on Page 19

Silicon Solar Cells

are gridded to increase efficiency

Silicon solar cells are now available with conversion efficiencies to 13 per cent. Cells are manufactured



How to expand without added expenditure

Right away let's make this point clear: you won't find any magic formula here for expanding your plant physically at no cost. What you *will* find are facts about a material that can definitely help expand your plant's productivity . . . and your product's salability.

That material is Masland Duran Clad, the new semi-rigid vinyl for laminating to metal sheets or coils according to your specifications . . . the built-in finish that obsoletes dipping, spraying, brushing, coating and similar finishing methods . . . the vinyl-to-metal laminate that can even do away with the need for having a finishing department.

Think what this can mean in terms of expanded productivity. Space now devoted to finishing operations can be used to expand your production area. Money currently spent in equipment, maintenance and finishing supplies can be channeled to more productive use. Costs of rejects, and the insurance costs of handling explosive materials can be eliminated, too, since Clad enables you to work with *prefinished* parts.

Consider, too, what Clad can mean in greater sales potential for your product. This durable, decorative vinyl can be produced in easy-to-clean colors . . . and in plain, textured or embossed designs. And here's the beauty of Clad from a production standpoint: It can be cut, crimped, drilled and even deep-drawn, without affecting color or design . . . without distorting the material itself . . . and without the need for any special processing equipment or methods.

Truly, Masland Duran Clad merits your most serious consideration right now . . . for, make no mistake about this: *vinyl-to-metal laminates are here to stay and grow.* With production soaring from one million square feet to 18 million in just three years . . . and from 125 to 165 million square feet estimated for 1961 . . . they are obviously lowering finishing costs and increasing design flexibility in a big way.

To safeguard and improve *your* competitive position, you will find it well worthwhile to mail this coupon for more information on Masland Duran Clad . . . and the laminators serving your area.

Industrial Products Division

THE MASLAND DURALEATHER COMPANY, Dept. MD, Philadelphia 34, Pa.

Masland Duran
CLAD
vinyl finish

THE MASLAND DURALEATHER CO., Dept. MD
Amber & Willard Sts., Philadelphia 34, Pa.

Please send information and samples of Clad

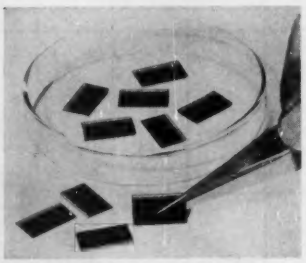
Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

Circle 303 on Page 19



with a number of secondary collector strips protruding from main or primary strip, affording better collection of current from active cell area. Cells are "gridded" because collectors form a grid network over active cell area. Higher operating voltage and lower impedance affords an increase in cell-output power over nongridded cells up to 20 per cent, under given light and load conditions. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 538 on Page 19

Silicone Rubber

provides strong bond to ferrous-containing metals

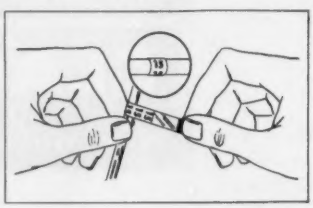
Designated SE-5504U, new self-bonding silicone rubber compound provides a strong, primerless bond to ferrous-containing metals. After cure, material has tensile strength of 1500 psi, tear strength of 200 psi, and elongation of 550 per cent. Rubber establishes a bond through a direct reaction with the metal surface. **Silicone Products Dept., General Electric Co.**, Waterford, N. Y.

Circle 539 on Page 19

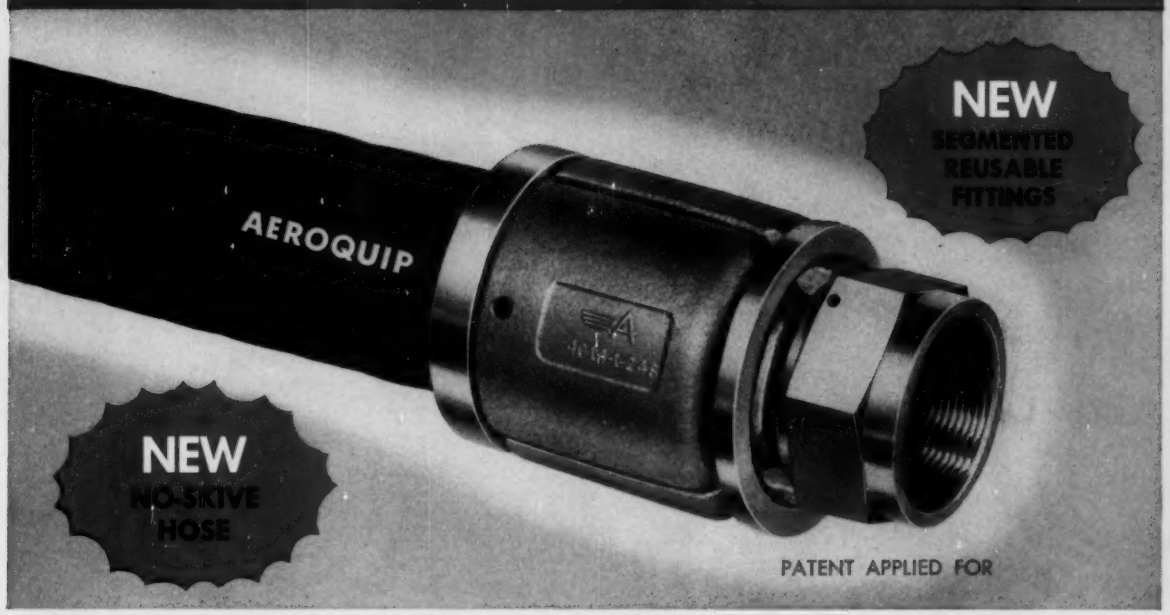
Wire Markers

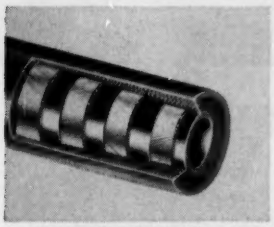
are self-adhering and self-laminating

E-Z-Code self-laminating wire markers, available in several lengths, resist all conventional oils, greases, chemicals, fluids, and other foreign matter. Each self-adhering marker is partly a precoded marker and

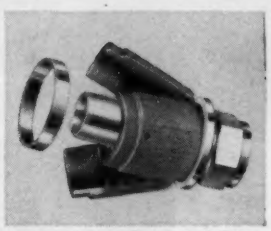


ANNOUNCING Aeroquip Super High Pressure Hose For Large-Diameter 3000 PSI Lines





Aeroquip 2755 Spiral Wrap Hose has synthetic rubber inner tube, with alternating layers of spiral wire wrapping and synthetic rubber. Recommended for high pressure hydraulic lines subject to high surge peaks.



Aeroquip's new Segmented Fitting was developed especially for 2755 Spiral Wrap Hose. This new reusable fitting assembles easily and quickly with hand tools. Hose need not be skived to attached fitting.

Aeroquip Segmented Fittings are quickly attached to 2755 Hose with this handy assembly tool. Just slide the nipple into the hose end, compress socket segments in place with the assembly tool and slip on a retaining band. The hose is ready for installation.

Now Aeroquip announces 2755 Spiral Wrap Hose developed especially to meet the increased demand for large-diameter high pressure hose lines. It is ideal for hydraulic systems where 1¼" to 2" hose sizes are required with working pressures up to 3000 psi.

The hose is constructed of alternating layers of spiral wire wrapping and synthetic rubber for flexibility and rugged service. Aeroquip Segmented Fittings are leakproof and blow-off proof, yet are completely detachable and reusable. For complete information, return the coupon for your copy of bulletin IEB-51.

Dash size	—20	—24	—32
O.D. tube size	1¼	1½	2
Hose I.D.	1.250	1.500	2.000
Hose O.D.	2.000	2.250	2.750
Working psi	3000	3000	2500
Min. burst psi	12000	10000	8000
Min. bend radius	18	22	26

all dimensions in inches

Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA • AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Aeroquip Corporation, Jackson, Michigan MD-4

Please send me a copy of Bulletin IEB-51 covering 2755 High-Pressure Hose and Segmented Fittings.

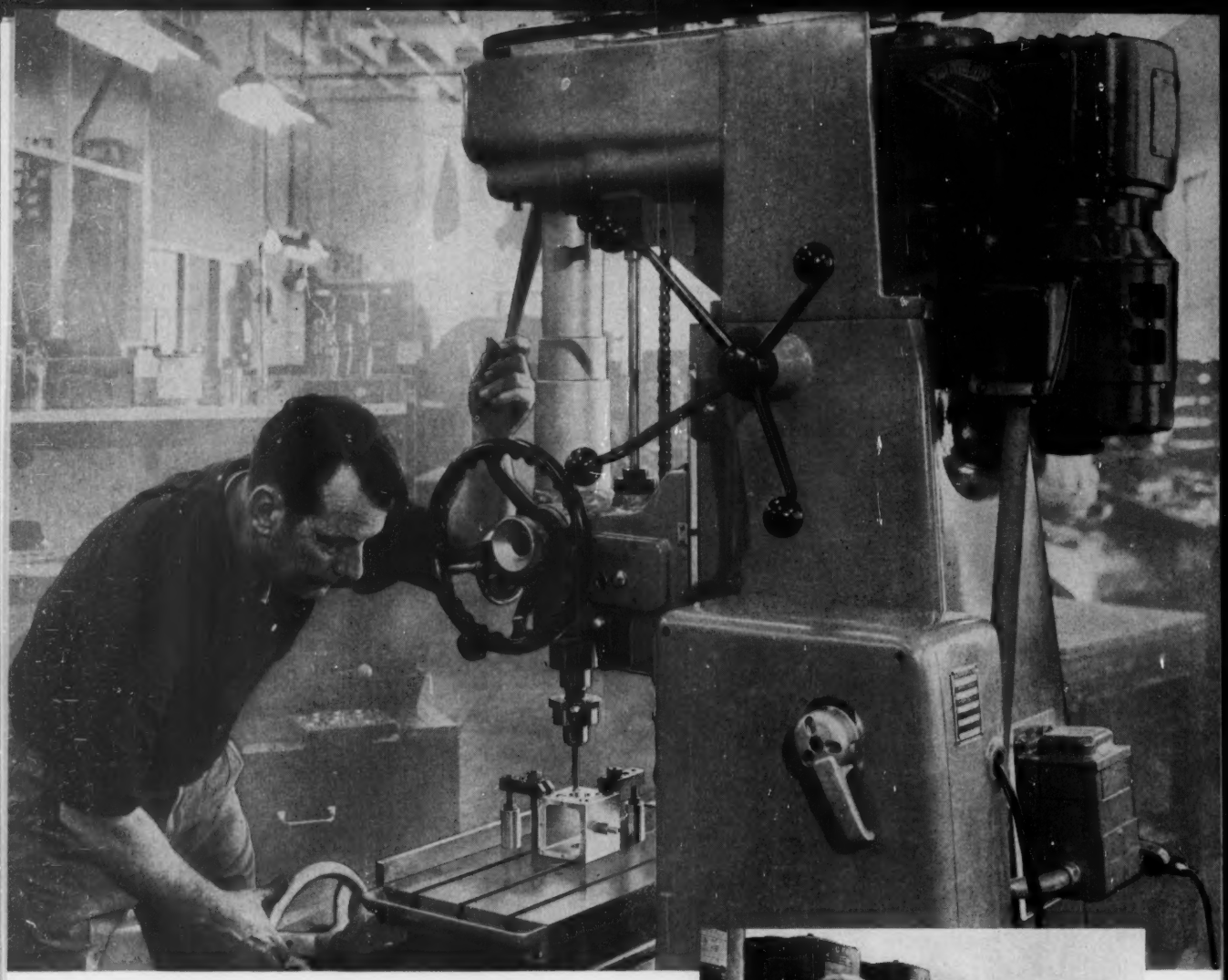
Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____



Mr. A. A. Lindberg, Design Engineer,
Moore Special Tool Co., Inc. states:
"On our Model 1½ Jig Borer...

General Electric Polydyne® Drives Help Us Maintain 0.000070"* Accuracy"

"Efficient control of vibration is the reason that the majority of our Model 1½ jig borers are equipped with General Electric Polydyne drives. Competitive drives have never fully solved this problem," states A. A. Lindberg, Design Engineer for Moore Special Tool Co., Bridgeport, Connecticut.

"Moore tests each Polydyne drive on a specially constructed bracket," continued Mr. Lindberg. "Vibration readings are taken at three points, and every Polydyne drive tested has been under the vibration limit of 0.001 inch and virtually free of operating noise.

"Another reason that our Model 1½ has proved popular is that the Polydyne drive gives an infinite number of operating speeds with just a simple adjustment of the dial to the desired rate."

When your application requires low-cost adjustable speed combined with reliability and ease of maintenance, investigate G-E Polydyne drives. Your General Electric Sales Engineer has full details. Or, write for bulletin GEA-6806, Section 854-06, General Electric Company, Schenectady 5, N. Y.

* Seventy Millionths

GENERAL ELECTRIC

Circle 306 on Page 19

partly transparent with a self-contained lamination extension. When a coded marker is applied around wire, remaining protective clear portion wraps around itself, causing it to laminate permanently over the coded area to protect it. Material is tough vinyl-plastic. **Westline Products Div., Western Lithograph Co.**, 688 E. Second St., Los Angeles 54, Calif.

Circle 540 on Page 19

Threaded Insert

for miniature sizes 0-80 through 3-48

Dodge Cone-Spread expansion insert provides durable brass threads in molded plastic. It is now available for miniature screw sizes 0-80 through 3-48. The one-piece brass insert works equally well in molded

or drilled holes in plastic components. As downward pressure is exerted on top of insert, cone section at base breaks free and is forced up into main portion of insert. Knurled portion of insert expands, forcing it into wall of molded or drilled hole and permanently anchoring the insert. Cone section is completely engulfed by the insert to give a flush base. **Phelps Mfg. Div., Heli-Coil Corp.**, Danbury, Conn.

Circle 541 on Page 19

Turns-Counting Dial

for shaft-controlled units of ten turns or less

Miniature turns-counting Microdial Series 3000, has 1 in. diam and projects from a panel 15/16 in. It provides accurate angular positioning of any precision potentiometer or shaft-controlled device of ten

PQA

proves it...

breaking point tests show Allen screws are consistently better

***PRODUCT QUALITY ASSURANCE**

PQA is the symbol of unquestioned quality at Allen. It stands for constant quality control from rigid upgrading of incoming raw materials to final, *unconditionally guaranteed* shipment to you.

To give you some idea: Federal Spec. FF-S-86a calls for 4,950 lbs. for the ¼-20 cap screw. Day-in, day-out breaking point tests of these screws prove that Allens are *consistently* better . . . well above the minimum requirement!

Quality checks like this one confirm PQA every step of the way through Allen's manufacturing process. And to help you keep costs down and profit margins up, Allen manufactures 1457 standard sizes.

Remember . . . it costs you no more to have *genuine* Allens right from stock, and they are only a minor fraction of your assembly costs.

Genuine ALLEN products are available only through your ALLEN Distributor. He maintains complete stocks close by to help cut your freight costs, inventory, warehousing and handling. He offers fast, single-source service. He knows Allen products. And he makes Allen Engineering Service available to you any time. Call him!

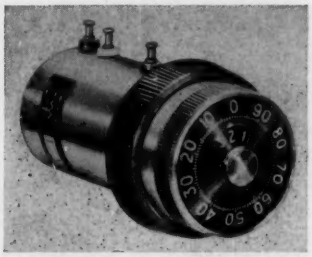
ALLEN

MANUFACTURING COMPANY

HARTFORD 1, CONNECTICUT, U.S.A.

Plant at Bloomfield, Connecticut • Warehouses in Chicago, Cleveland and Los Angeles

ALLEN HEX-SOCKET SCREWS HEAD



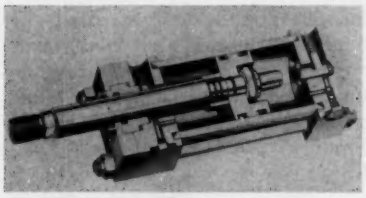
turns or less. Standard models accommodate shafts of either ⅛ or ¼ in. Five brake knob colors and three combinations of numeral and background colors are available as well as fluorescent numerals. **Borg Equipment Div., Amphenol-Borg Electronics Corp.**, 120 S. Main St., Janesville, Wis.

Circle 542 on Page 19

Hydraulic Cylinders

in bores from 1½ to 6 in. for low-pressure use

New low-pressure hydraulic cylinders for use where high-pressure functions are not required range in size from 1½ to 6-in. diam bores. They are for pressures to 1500 psi. Features include a steel barrel for rigidity, and close-fitting iron piston for long bearing area. New seal arrangement automatically lubricates the bearing at all times. **Milwaukee Cylinder Co.**, Cudahy, Wis.

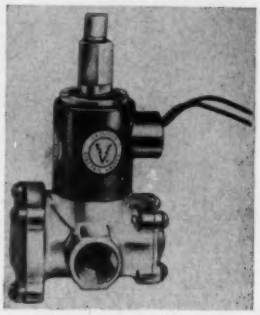


Circle 543 on Page 19

Solenoid Valves

for use in hazardous locations

Three-way explosionproof solenoid valves with a ½-in. main orifice and ½-in. NPTF are for use in hazardous locations. The high-flow valves are available normally open, normally closed, and with directional control, with operating-pressure differentials of 5 to 150 psi. The ½-in. explosionproof valves of



the L Series have naval forged-brass bodies and internal parts of brass and stainless steel. They are available in a wide range of voltages and frequencies. **Skinner Electric Valve Div., Skinner Precision Industries Inc., New Britain, Conn.**

Circle 544 on Page 19

Self-Adhesive Nameplates

of aluminum foil or polyvinyl chloride

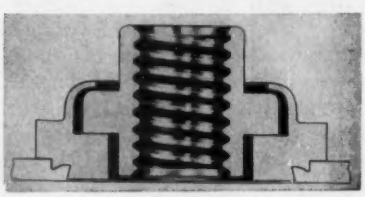
Self-adhesive nameplates, mounted on dispenser cards, are available in aluminum foil or polyvinyl-chloride materials. Aluminum-foil nameplates resist solvents, oil, and dirt. They are heat resistant to 350 F, and printing is permanently debossed in the nameplate. Foil is 3-mil thick. Vinyl nameplates are used wherever permanent color identification is desired. Made of 6-mil vinyl plastic, they conform to virtually any surface. Printing is unaffected by oil, moisture, abrasion, or weather. **Dept. 702, W. H. Brady Co.,** 727 W. Glendale Ave., Milwaukee 9, Wis.

Circle 545 on Page 19

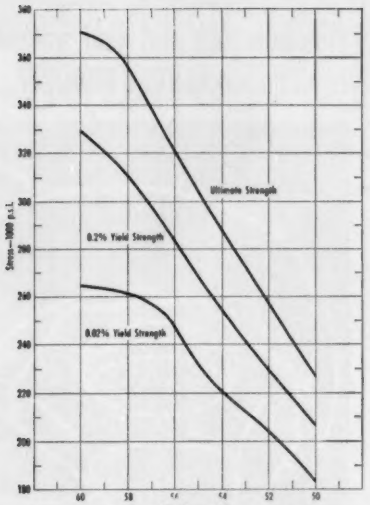
Self-Locking Fastener

for sheet thicknesses of 0.040 and higher

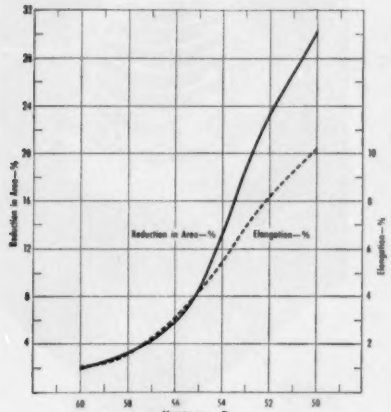
Clinched by a squeeze into prepared holes, new nut provides a rapidly assembled nut anchor in sheet metal, and compensates for errors to 1/32 in. in alignment of



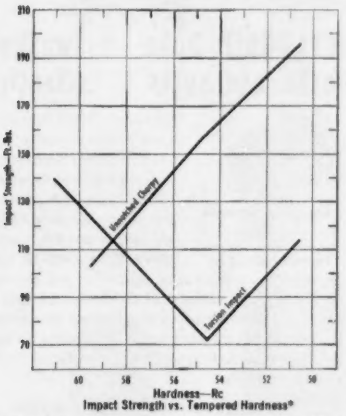
Circle 310 on Page 19



Tensile and yield strength as a function of hardness*



Ductility of HI Shock 60 as a function of tempered hardness*



Impact Strength vs. Tempered Hardness*

*Austenitized 1600°F, 20 minutes at heat, air cooled. All tempers 1 hour at heat.

NEW ultra high strength steel... for critically-stressed components

Carpenter HI SHOCK 60 is a new air-hardening steel for applications requiring extreme shock resistance. It can be heat treated to tensile strength in excess of 350,000 psi and retain substantial ductility and impact strength at that level. In addition to exceptional toughness, its benefits include good machinability and a low hardening temperature. As an ultra high strength steel, it is recommended for critically-stressed components where maximum strength must be combined with least sacrifice of toughness.

These tables and graphs will help you to determine whether or not HI SHOCK 60's unique combination of properties provides a suitable solution for any of your current design problems. By using the coupon below you can get more detailed technical data as well as an actual sample of this new ultra high strength steel to test in your own plant.

Mechanical properties:

Effect of tempering temperature on Tensile Properties

Austenitized 1600°F, 20 minutes at heat, air cooled, tempered as indicated, one hour at heat.

Tempering Temp.	0.02% Yield Strength	0.2% Yield Strength	Ultimate Strength	Elongation %	Reduction of Area %	R_c
475°F	259,000	316,000	363,000	1.6	3.1	58
675	251,500	283,000	320,000	3.5	7.8	56
800	224,500	259,000	295,000	4.0	8.5	54
1000	204,500	229,000	251,000	8.2	23.5	52
1075	184,000	206,000	226,000	10.2	30.9	50

Effect of tempering temperature on Impact Properties

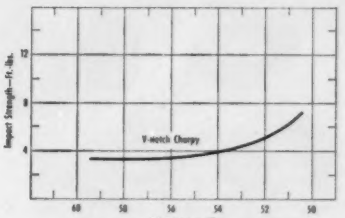
All specimens austenitized 20 minutes at 1600°F, air cooled, tempered as indicated, one hour at heat.

A. Unnotched Charpy			B. V-notch Charpy		
Tempering Temp.	Av. Ft.-lbs.	R_c	Tempering Temp.	Av. Ft.-lbs.	R_c
375°F	102	60	375°F	3.5	59.5
700	158	55	700	3.5	54.5
1050	191	50.5	1050	7.0	50.5

Thermal expansion properties:

Temperature from 75°F to	Coefficient in/in/°F x 10^{-6}
122°F	4.76
212	5.12
302	6.41
392	6.87
482	7.21
572	7.38
662	7.33
752	7.03
842	6.52
932	6.46
1022	6.50
1112	6.66
1202	6.81
1292	6.89

Critical Temperature Ac_3 = 1435°F. Austenitized 20 minutes at 1600°F, air cooled, tempered one hour at 350°F.



V-Notch Charpy Impact Strength vs. Tempered Hardness*

Use this coupon for more data... free sample

Attention: T. A. Washburn, Manager, Tool Steel Sales
The Carpenter Steel Company, Dept. 188, Reading, Pa.

☐ Send HI SHOCK 60 Technical Data Sheet
☐ I'd like a sample of HI SHOCK 60 for testing

Name_____
Title_____
Company_____
Street_____
City_____
Zone_____ State_____

Carpenter steel

you can do it **consistently** better with Carpenter Tool and Die Steels

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Export Dept., Port Washington, N. Y.—"CARSTEELCO"
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

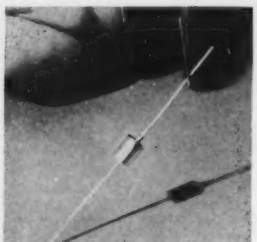
mating holes. Available in sizes No. 4 to ¼ in., it is suitable for sheet thickness from 0.040 in. up and materials with hardness of Rockwell B70 or less. Threads are class 3B. Type LAS has cadmium or cadmium-chromate, finished-steel retainer with nut of 18-8 stainless steel, passivated, and with dry-film lubricant; type LAC is stainless steel throughout, passivated, and with dry-film lubricant. **Penn Engineering & Mfg. Corp.**, Doylestown, Pa.

Circle 546 on Page 19

Silicon Rectifiers

for 1 ma continuous duty

Silicon rectifiers are available in a silver-flashed-metal and epoxy package, or in a hermetically sealed, flangeless, glass - to - silver - flashed-metal package. They are rated for



1 ma continuous duty from 400 to 1000 peak inverse voltage. Units have single-ended leads for use in printed-circuit boards or standard axial-type leads. Case measures ¼ x 5/16 in. **Electronic Devices Inc.**, New Rochelle, N. Y.

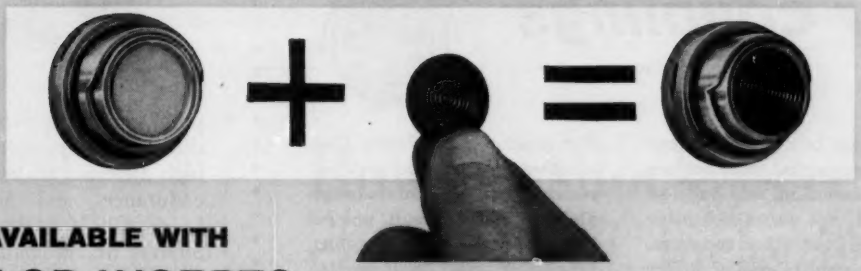
Circle 547 on Page 19

Encapsulated Motors

are random-wound, ac induction units

Open, dripproof motors, 445U frame sizes and smaller, 600 v and below, incorporate Capsular insulation system which provides added protection against moisture, chemicals, oils, and abrasive contaminants in adverse environmental atmospheres. Smoothly encapsulated, voidfree, conventionally wound stators feature heat-resistant plastic-resin that completely seals end coils and fills spaces between wires in the stator slots with a moisture-

Square D's ALL-METAL Push Buttons give EXTRA DURABILITY!



NOW AVAILABLE WITH

COLOR INSERTS—with these Important Advantages:

Longer lasting • Indestructible operator is made entirely of metal. High-density polyethylene inserts are permanently colored, won't fade or deteriorate on even the toughest jobs. Push buttons are completely oil-tight, even when depressed.

Reduce your inventory • Order push buttons in color desired, or get the new "universal" package containing a basic operator and seven different color inserts—no extra cost. Inserts just snap in, can be changed in seconds if necessary.

7 colors available • Choose from black, red, green, brown, yellow, orange, blue.

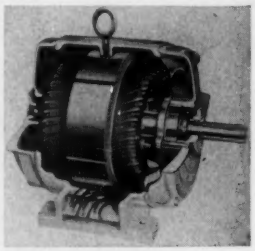
Complete flexibility • Any operator can be used with any contact block to meet every requirement. Contact block arrangements include single-pole double-throw, two-pole double-throw, four-pole double-throw, sequence closing, and overlapping contacts.

A COMPLETE LINE OF OIL-TIGHT OPERATORS

Write for Bulletin 9001-T. Square D Company, Dept. SA, 4041 No. Richards St., Milwaukee 12, Wis.

SQUARE D COMPANY

wherever electricity is distributed and controlled



proof, chemical-resistant protective sheath. Encapsulating material has high dielectric strength and thermal endurance, and high resiliency. **Louis Allis Co., Dept. P., 427 E. Stewart St., Milwaukee 1, Wis.**

Circle 548 on Page 19

Elapsed-Time Indicator

is designed for easy reading

Commercial elapsed-time indicator registers hours and tenths and minutes and tenths to 99999.9. Indicator is designed for easy reading. Face has direct-reading counter and large, clear numbers. Resettable and nonresettable models are available with either 3½-in. diam round bezel or 3 x 3-in. square bezel. All models have screw-type terminals for convenient installation, operate at 120 or 240 v ac, 50 or 60 cps. Input is 5.0 w at 60 cycles or 3.4 w

at 50 cycles. **Haydon Div., General Time Corp., 245 E. Elm St., Torrington, Conn.**

Circle 549 on Page 19

Self-Sealing Screws

seal internal and external pressures over 500 psi

KaptOskrews are self-sealing captive screws available in thread sizes from 2-56 to ¼-20. Only one length is required for each thread size, but each size accommodates all panels or covers from 1/32 to ¼ in. thick. No tapping of the

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of joints in corrosive environment

For a fastener to stand up in a corrosive environment it must either be coated, or made from an anti-corrosive metal.

THE METALLIC COATINGS

The "workhorse" applications are satisfied most economically with SAE Grade 2 or Grade 5 fasteners. Required outdoor durability is achieved with a plated or a hot galvanized finish. Hot galvanizing complicates good thread fits, costs more than plating in the popular size range, but gives much greater protection than any commercial plating.

A heavy galvanized coating is not recommended on highly stressed fasteners. If you need the high strength of Grade 5 bolts and want them corrosion-resistant, zinc plating should be your first choice. Certain conditions may require cadmium, nickel or copper plate.

THE ENDURING METALS

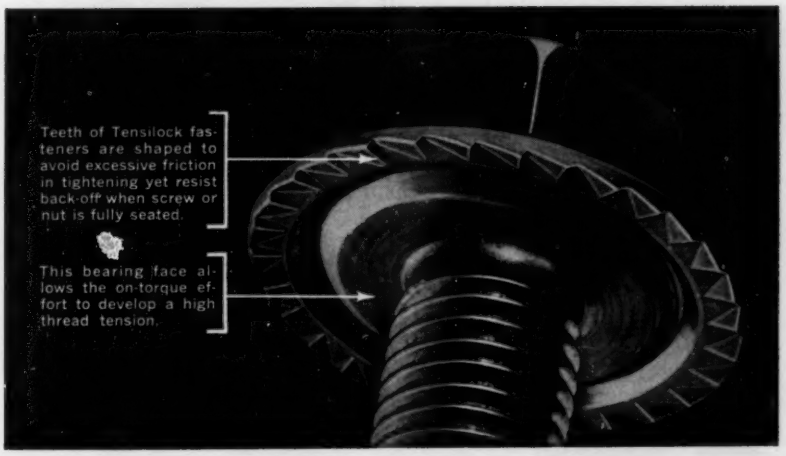
While each metal poses problems in certain applications, stainless steel, aluminum, and silicon bronze all offer distinct advantages.

Silicon bronze is popular for electrical uses due to its unusual strength, resistance to stress-corrosion, good conductivity.

Aluminum fasteners afford light weight as well as excellent conductivity. Anodized, they provide various colors; better corrosion resistance.

Widely used for fasteners, the 18-8 grade stainless steel assures good strength and excellent corrosion resistance in most atmospheres.

How Tensilock® Screws clamp tight, lock tight



TENSILOCK screws belong in the same league as high strength hex screws. With the same on-torque effort, the Tensilock units develop about 90% of the thread tension usually developed by the latter. Thus, they *both* make strong joints.

THREAD TENSION = CLAMPING FORCE

In theory, the higher the thread tension, the stronger the joint and the higher the inherent ability of the fastener to stay tight. In practice,

Screw Diameter		¼	⅜	½
Thread Tension (lbs.)	Tensilock	2,750	6,750	12,400
	High Strength Hex	2,975	7,250	13,300
On Torque (inch lbs.)	Both	120	420	1,000
Off Torque (inch lbs.)	Tensilock	150	525	1,250
	High Strength Hex	95	330	800

you derive these benefits by torquing a high strength screw close to its *yield strength*. But what if you need high thread tension plus *extra* assurance that joints will stay tight? Then you have a job for Tensilock units. Not only do they develop the high thread tension, but also have an extra (and *integral*) locking device.

OFF-TORQUE = LOCKING POWER

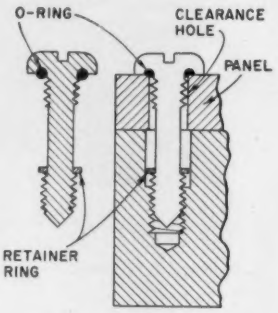
By design, loosening torque of Tensilock fasteners exceeds tightening torque by 25% or more. This is an effective "lock." It gives that extra margin of safety against vibratory loosening.

To sum up: RB&W's Tensilock screws are stronger than Low Carbon Hex Screws; compare with High Strength Hex Screws in clamping force; are superior to them in locking action. Suggestion: For a strong locking *bolt*, use with Tensilock Nut. Send for Bulletin TL-2. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Sales office and warehouse at: San Francisco, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas.

Circle 317 on Page 19

panel is required for installation, and units can be used in standard clearance holes. Standard fasteners are pan-head screws in stainless steel, with silicone rubber O-rings. Screws seal internal and external pressures in excess of 500 psi, and can be tightened and loosened



many times without losing the seal. A. P. M. Corp., 41 Honeck St., Englewood, N. J.

Circle 550 on Page 19

Cable Clamp

for use on electronic equipment

No. 1025 waterproof cable clamp is for use on electronic equipment exposed to water or fumes to bring a power cable or similar unit into the waterproofed equipment. Clamp, equipped with O-rings and rubber

compression grommets, is available in several sizes (shown). Vemaline Products Co., Franklin Lakes, N. J.

Circle 551 on Page 19

Metal Swivel Joint

for temperatures from −425 to +1500 F

All-metal swivel joint incorporates a welded-metal bellows to replace traditional elastomers. Operating range is −425 to+1500 F. Pressure capability is 1500 psi, higher if

RUBBER in Design Engineering

PROPERTIES	Non-Oil Resistant			Oil Resistant	
	Natural	SBR	Butyl	Nitrile	Neoprene
Tear Resistance	Excellent	Poor-fair	Good	Fair	Good
Abrasion Resistance	Excellent	Good	Good	Excellent	Excellent
Compression Set Resistance	Good	Good	Good	Very good	Good
Permeability to Gases	Fair	Fair	Excellent	Very good	Very good
Aging (Sunlight)	Poor	Poor	Excellent	Fair	Excellent
Aging (Oxidation)	Good	Good	Good	Fair	Good
Aging (Heat, max. temp. F)	200	250	300	250	250
Solvent Resistance (Aliphatic Hydrocarbons)	Very poor	Very poor	Poor	Good-Exc.	Fair
(Aromatic Hydrocarbons)	Very poor	Very poor	Poor	Fair-good	Poor
Oil Resistance (Low Aniline)	Very poor	Very poor	Very poor	Fair-Exc.	Fair
Oil Resistance (High Aniline)	Very poor	Very poor	Very poor	Fair-Exc.	Good
Gasoline Resistance (Aromatic)	Very poor	Very poor	Very poor	Fair-good	Fair
Gasoline Resistance (Non-aromatic)	Very poor	Very poor	Very poor	Good-Exc.	Good
Cold Resistance (Min. svc temp. F)	—65	—70	—65	—65	—50

This table gives you an idea of how some rubbers react to various conditions. In designing, consult your Garlock rubber specialist to achieve best application results.

Garlock offers dozens of different types of rubber, each carefully chosen and processed to meet your exacting needs . . . natural rubber with high tensile strength where real "rubber-like" properties are required . . . styrene butadiene rubber, the work horse of the industry—a low cost material for use where a good, rugged general purpose compound is required . . . neoprene rubber where good oil and abrasion resistance and aging characteristics are important. In addition, Garlock offers a wide range of nitrile and butyl compounds where their special properties are required. For more difficult applications Garlock offers a complete line of specialty rubbers from silicone for high and low temperature service to VITON* for extreme temperature and solvent resistance.

Thoroughly tested to meet ASTM standards. Over twenty various tests are conducted on rubber materials before, during, and after manufacture to assure top performance. First, the rubber is carefully compounded and mixed exactly to specification. Then it is measured for durometer hardness, tensile strength, elongation . . . resistance to water, weather, temperature . . . many other vital characteristics. Scientific measurements like this, using ASTM, SAE-ASTM, and military standards—plus quality control during manufacture—assure you of the finest rubber parts available.

No two rubbers are alike. Each has its own individual strong points; each performs better under one set of conditions than another. In the design stage, call in your Garlock representative. He's a specialist in rubber parts and will assist you in selecting the proper material. Then, too, he may have several cost-saving ideas to suggest. You

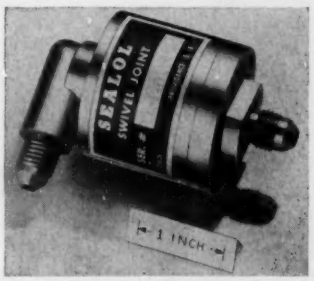
GARLOCK

can reach him at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or, write for Catalog AD-167, Garlock Inc., Palmyra, N. Y.

Canadian Div.: Garlock of Canada Ltd.
Plastics Div.: United States Gasket Co.

Order from the Garlock 2,000 . . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*Du Pont Trademark



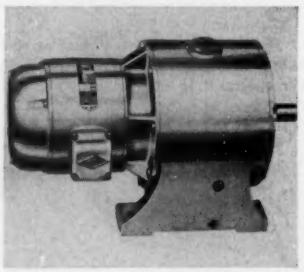
desired. Swiveling torque is held to a minimum, 4 lb-in. at 1500 psi. Swivel is available in 1/4-in. tube size; other sizes on request. **Sealol Inc.**, Providence, R. I.

Circle 552 on Page 19

Motor Reducers

for use where low-speed, high-torque output is needed

Helical Motoreducers are available as integral motor and gear-reducer packages in all ratings from 1/2 through 50 hp. Each unit is also available as standard with a wide selection of drive motors including Fluid-Shaft, wound-rotor slip ring, squirrel cage, crane-hoist and torque, in drip-proof or totally enclosed types. Applications are found wherever machinery requires a low-speed,



high-torque output. Gear reduction ratios are supplied from rated motor speeds down to 520 through 9 rpm output shaft speeds. **Reuland Electric Co.**, Alhambra, Calif.

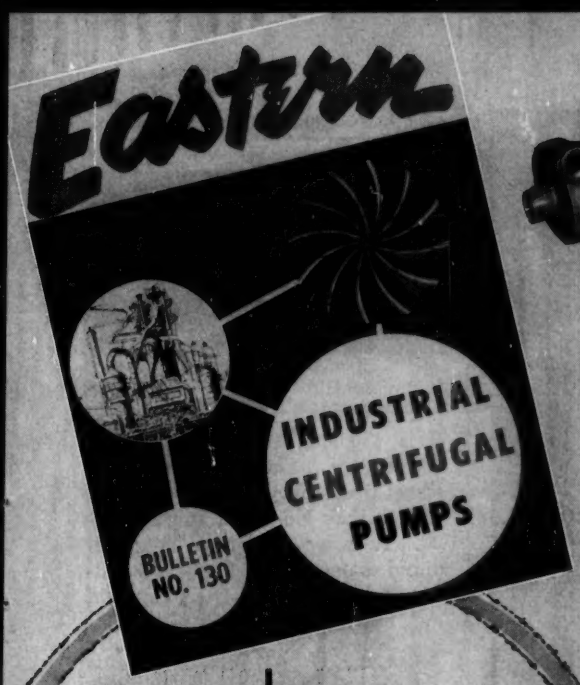
Circle 553 on Page 19

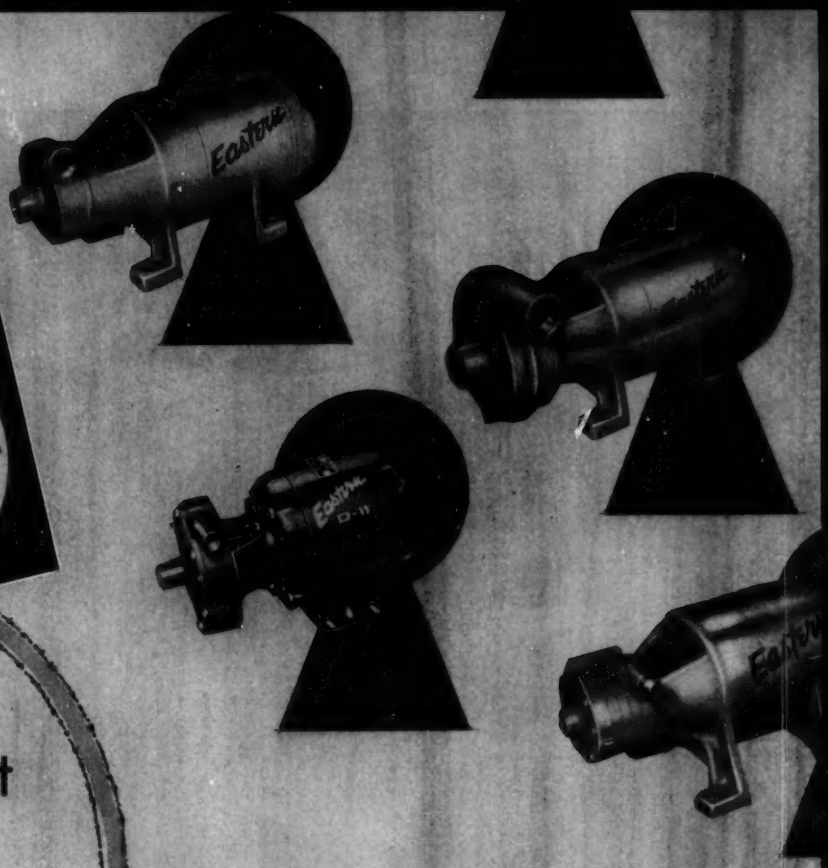
Lock Nut

for 1400 F applications

Designated FN 1418, one-piece self-locking nut of Waspalloy, a nickel-base alloy, is intended for use with high-performance bolting at temperatures to 1400 F. Nut has high reusability and lock retention. It is rated at a room-temperature min-

Circle 322 on Page 19→





your key to the perfect choice of CENTRIFUGAL PUMPS

A new catalog opens wide the doors to designers of process equipment — tells all you need to know in terms of engineering data, performance charts, seals, metals, mountings!

If you need centrifugal pumps with these characteristics, this reference book is for you:

- PRESSURES: to 21 psi in single stage pumps; to 70 psi in multi-stage types.
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- MOTORS: standard motors for 115/230 volts 60 cycles 1 phase (other electrical characteristics available). Power range from ⅛ to 1½ H.P.
- ENCLOSURES: drip-proof, totally enclosed, and explosion-proof ballbearing frames.
- DRIVES: Space-saving close coupled pumps most rugged and popular. Pedestal mounted arrangement without motor available as alternate for belt or coupling drive.
- SEALS: a variety of rotary seals and stuffing boxes, to fit every application.
- METALS: your option of cast iron, bronze, stainless steel, Monel, Cast Iron, Hastelloy "C".
- INSTALLATIONS: a wide range of transfer, recirculation, feed, boost and filter-pumping applications.

All told, 50 different models are described in full — and you get a wealth of technical data as well. Write for new catalog 130 now!

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EASTERN INDUSTRIES, INCORPORATED

100 SKIFF STREET, HAMDEN, CONN.
WEST COAST OFFICE 4203 Spencer St., Torrance, Calif.

imum tensile strength of 180,000 psi; minimum tensile rating at 1200 F is 130,000 psi, and at 1400 F, 100,000 psi. The twelve-point external-wrenching lock nut is available in sizes No. 10-32 through ½-20. It is for use on 0.003-in. reduced diameter bolt threads. **Standard Pressed Steel Co.**, Jenkintown, Pa.

Circle 554 on Page 19

Midget Bearings

are now available in enlarged range of sizes

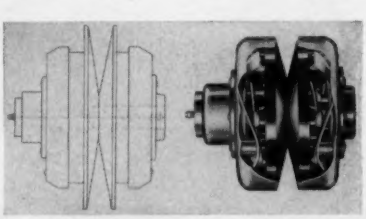
Permanently lubricated, self-aligning midget bearing cartridges now include shaft sizes from ⅛ through ⅝ in. Originally designed for small fractional-horsepower electric motors, they now have many other applications. **Randall Graphite Bearings Inc.**, Greenlawn Avenue, Lima, Ohio.

Circle 555 on Page 19

V-Belt Pulleys

are rated 1 to 5 hp at 1750 rpm

New cam control design to assure variable-speed efficiency is a feature of wide V-belt pulleys rated at 1 to 5 hp at 1750 rpm. They provide instantly variable ratios to 3:1. Each pulley face is independently actuated by its own spring and cam assemblies. Opposite wedging action of each cam and cam follower prevents pulley spread, assuring constant speed at all times. Depending on the model, pulleys use No. 087, 12, or 14 top-width variable-speed belts. Standard bore sizes are ⅝ to



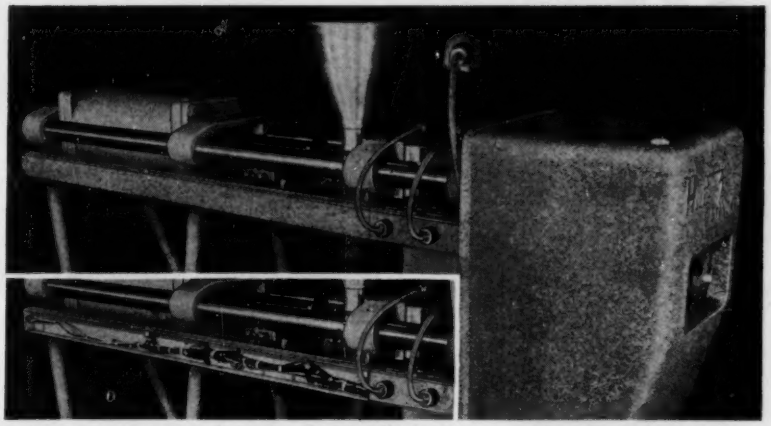
Machine has electrical raceway built in

Plugmold raceway places outlets conveniently; houses wiring systems and other devices

More and more standard units and variations of Plugmold multi-outlet systems are being built into original equipment — such as this Hull-Standard Model 99-A Molding Press (Hull Corp., Hatboro, Pa.). This press uses two lengths of Plugmold 3000 on the frame, one as a housing for the wiring system, the other for housing pipe lines.

Plugmold was easily adapted for this application. Holes were drilled for three switches and two indicators located on top of the run. Plug-in, plug-out convenience is provided for the heating coils; a work light is also included. Wiring is easy to get at, simply by removing the raceway cover (see photo inset).

In the same position on the opposite side of the press, Plugmold 3000 makes a neat housing for three pneumatic pipe lines from compressor to direction control valve.



Plugmold on molding press holds wiring for light, indicators, heating coils, and switching.

Wide choice for designers

Plugmold is made in a number of sizes, with almost unlimited choice of outlet types and spacings. Modifications of standard product engineered to meet specific or special requirements can be made; for example, factory-wired and assembled Plugmold incorporating circuit protective means on the channel (fuse or circuit breaker), portable power strips with provision for easy connect and disconnect, Plugmold wired with multi-prong jacks for control circuits, etc.

Wiremold welcomes the opportunity to assist in developing special Plugmold multi-outlet assemblies.

Designing with duct:

Unique construction has hidden values

When you are designing with flexible duct, look into the extra values of Wiremold's mechanical construction (see cutaway).

While Wiremold's six standard types meet most needs, the mechanical construction permits use of other fabrics and metals. This mechanical lock does not require adhesives, assuring long life.

The metal spiral, being flat, speeds your assembly line too. Close ID tolerances assure an easy, snug fit to connectors. In seconds, duct is fastened by securing 2 or 3 drill screws through the flat spiral and connector. There's no need for clamps — or cuffed ends — although cuffs are available for those applications where quick disconnect is needed. Special shapes (e.g., square, oval) can also be furnished.

Unique mechanical construction — fabric is locked to flat metal spiral — has many advantages. For one, fast hook-ups to connectors with drill screws, for a non-slip grip.

D1-4

WIREMOLD ■ HARTFORD 10, CONN.

Send information on:

☐ PLUGMOLD ☐ WIREMOLD AIR DUCT

name

company

address

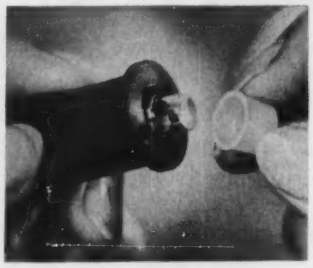
1⅛ in. and keyways are 3/16 x 3/32 and ¼ x ⅛ in. Pulleys are designated Models 1060, 1160, 1280, 1390, and 1590. **Lovejoy Flexible Coupling Co.**, 4932-H W. Lake St., Chicago 44, Ill.

Circle 556 on Page 19

Pushbutton Switch

accepts eight voltages of indicator lamps

Illuminated indicator switch is a compact, flexible unit which accepts eight indicator lamps with voltages from 4 to 48. Five colored, translucent-nylon caps can be replaced from the front of panels, and lamps can also be replaced in the same



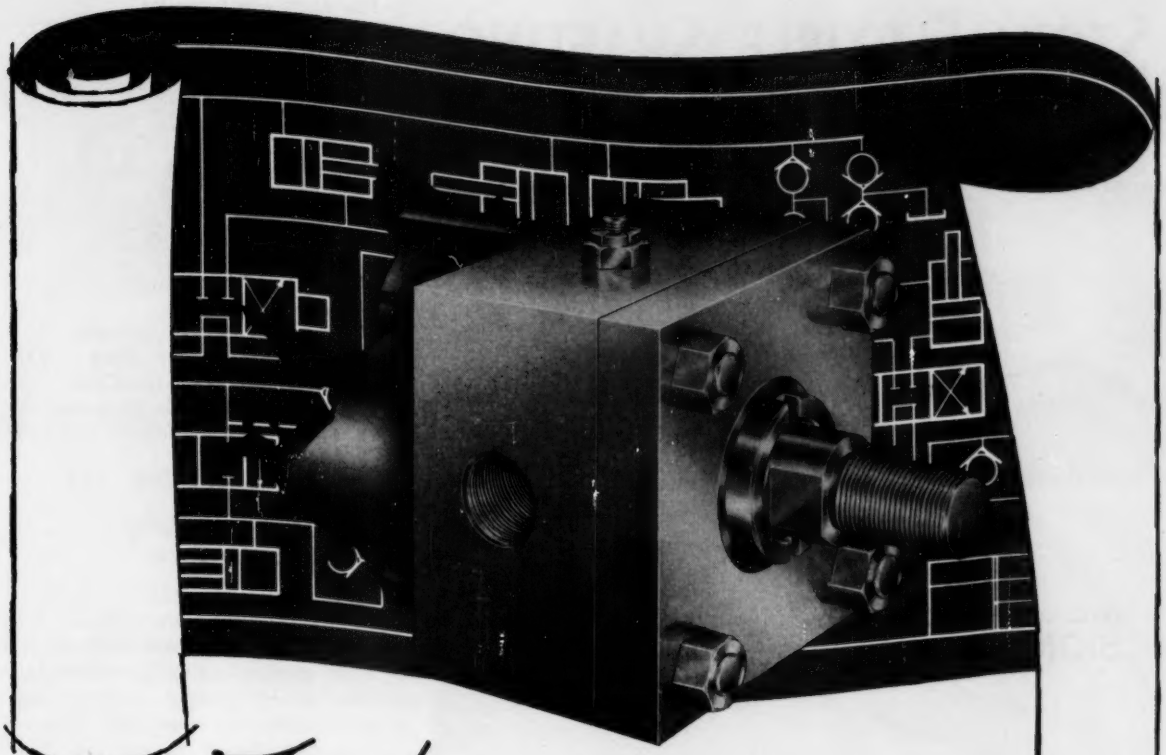
manner. Switch has 41/64-in. diam and mounts with a Tinnerman clip. **Lighting Products Div., Sylvania Electric Products Inc.**, 60 Boston St., Salem, Mass.

Circle 557 on Page 19

Dual-Purpose Valve

for pneumatic service

Single, compact valve serves the purpose of either a quick-exhaust or double-check valve for pneumatic service. Operating on a pressure differential, valve is completely self-contained. Used as a quick-exhaust unit, it can be mounted on or near the cylinder port. The moment pressure from the control valve is released, the valve dumps exhaust air from the cylinder directly to atmosphere, eliminating line friction and control-valve restriction. As a double-check or shuttle valve, it can be used to connect two independent air supply or control lines to a common line. Aluminum-bodied valve operates at pressures to 200 psi, has a 1¾ in. diam, is 2½ in. long, and has three ⅜-in. NPT female ports. Only



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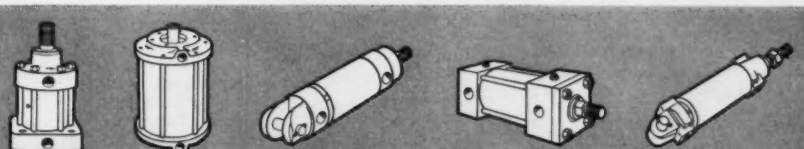

STANDARD HYDRAULIC | STANDARD PNEUMATIC | AIR and HYDRAULIC SPACEMAKER | AIR and HYDRAULIC SQUAIR HEAD | HIGH PRESSURE SPACEMAKER

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Representation in all major areas, including Canada.

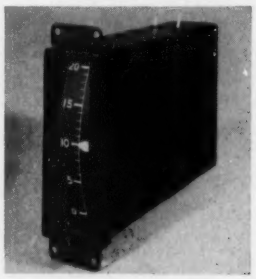
moving part is the neoprene diaphragm. **Modernair Corp.,** 400 Preda St., San Leandro, Calif.

Circle 558 on Page 19

Edgewise Meters

ac and dc units for severe environments

Long-scale, 3-in. MDE-3 edgewise dc and ac meters are available for use in control console and equipment applications where reliable indication is required under severe environmental conditions. Hermetically sealed meters are furnished in a selection of dc current (200 ma and up) and voltage ranges, as well as in rectifier-type ac styles. Mechanism is shielded and panel material has no influence on calibration. Units can be mounted horizontally or vertically. Case size of 3.7 x 6.1 x 1.3 in. makes it possible to mount the meters close together and to obtain in-line



readout. **Precision Meter Div., Minneapolis-Honeywell Regulator Co.,** Grenier Field, Manchester, N. H.

Circle 559 on Page 19

Trimming Potentiometer

is ⅜ in. square by 0.140 in. thick

Series 200 Squaretrim precision subminiature trimming potentiometer in 72 standard models is designed

ASARCON

custom shapes and forms in any lengths you need

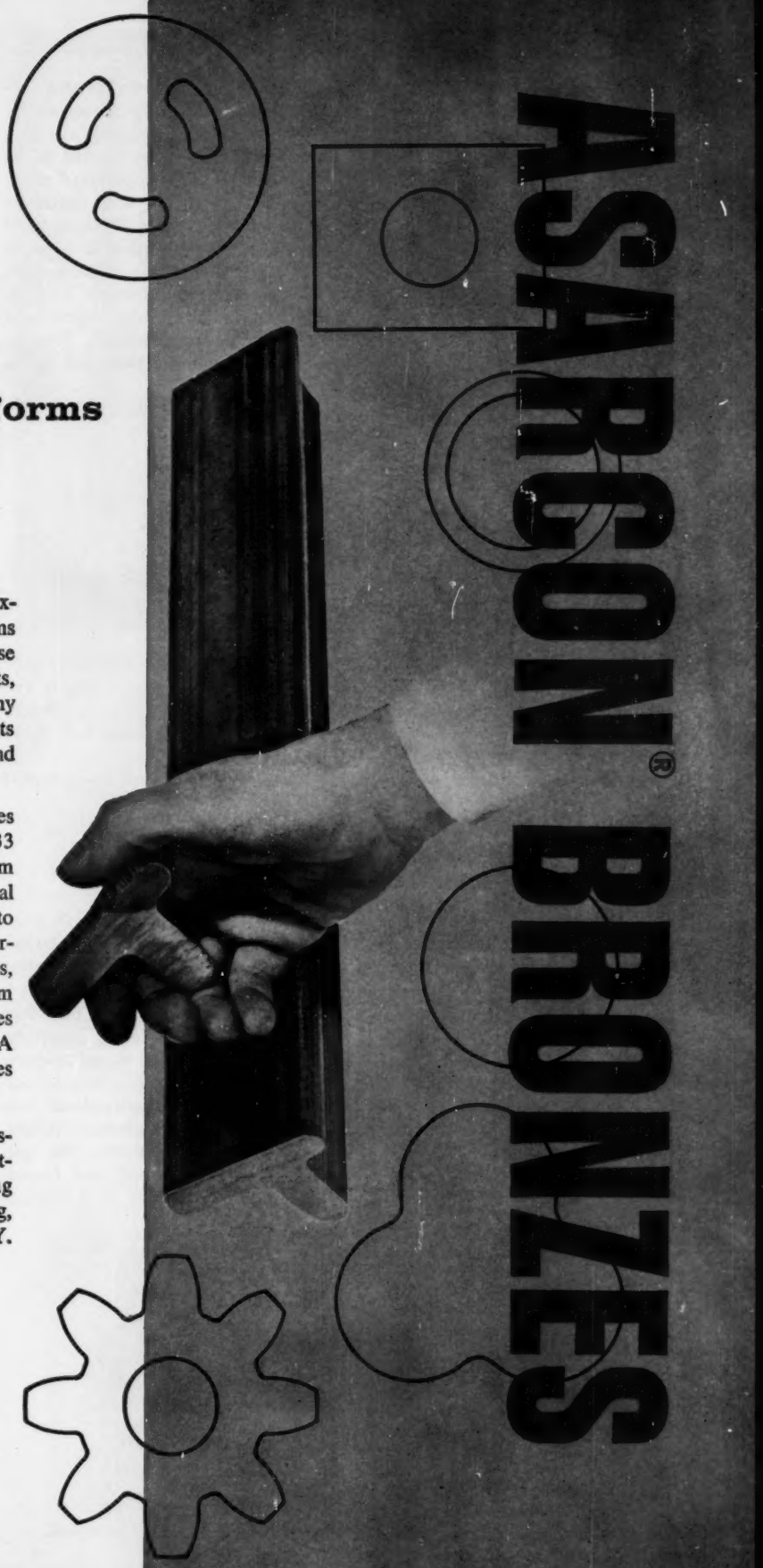
Asarcon continuous castings give you an extremely wide variety of shapes and forms in standard bronze alloys. They will increase your production rates and lower your costs, because: you get the shape you want in any length you need up to 20 feet. This permits machining on automatic screw machines and other high-speed equipment.

Continuous casting of Asarcon bronzes raises fatigue characteristics of standard alloys 33 to 100%, increases impact strength from 15% to more than double that of identical alloys cast other ways, adds materially to tensile, yield strengths and hardness. Asarcon 773 (SAE 660) bearing bronze in solids, rods and tubes is immediately available from stock in your choice of more than 260 sizes up to 9" O.D. and lengths up to 105". A wide variety of other special alloys, shapes and sizes produced to order.

For complete data on Asarcon continuous-cast bronze, write Continuous-Cast Department, American Smelting and Refining Company, Perth Amboy, N. J., Whiting, Ind.; or 120 Broadway, New York 5, N. Y.

ASARCO

Circle 329 on Page 19



with pins or flexible nylon and Teflon leads. Unit is $\frac{3}{8}$ in. square by 0.140 in. thick, permitting as many as 28 trimmers to be stacked in $\frac{1}{2}$ cu in. Operating temperature range is −55 to +150 C, with resistance values provided from 10 ohms to 50 kilohms. Power rating is 1 w in still air. Worm-gear adjusting device provides high-friction loading, assuring smooth, stable adjustment and eliminating backlash. Friction between aluminum case and nylon

worm gear locks wiper in place after each adjustment and holds it fast against shock or vibration. **Potentiometer Div., Daystrom Inc.**, Archbald, Pa.

Circle 560 on Page 19

Limit Switch

has built-in neon indicator lamp

Model 1LS501 compact limit switch incorporates a built-in indicating lamp. Normally on when switch is not actuated, lamp goes off when switch arm is actuated. Lamp insert can be installed in switch cover to make contact with either the normally-open or normally-closed contacts of the switch element. Aluminum housing protects the precision switch element, and forged-aluminum arm has a hardened-

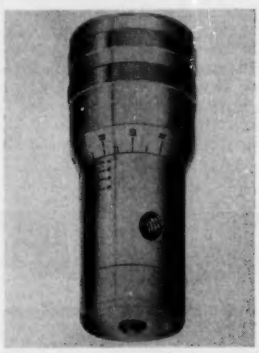
steel roller. Housing has four tapped holes for 1/4-20 UNC screws or No. 10 clear bolts for mounting. For conduit connection, a 1/2-14 NPT threaded opening is provided. **Micro Switch Div., Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

Circle 561 on Page 19

Pressure Regulator

has micrometer adjustments

Model R 4009 pressure regulator, suitable for supply pressures to 150 psi, maintains a precise outlet pressure with varying inlet pressure or flow. Pressure balanced, low flow-force spool instantly corrects for changes. Regulated pressure accuracy is ±0.25 per cent with varying inlet pressures. Full-flow porting and sensitive control actuation accommodate high flow rates in minimum size without pressure drop. Low friction and low flow-force resistance insure accuracy with minimum hysteresis. Finger-tip micrometer adjusts instantly, and can be reset with a normal repeatability of



±0.5 per cent. **Circle Seal Products Co. Inc.**, 2181 E. Foothill Blvd., Pasadena, Calif.

Circle 562 on Page 19

Fractional-Horsepower Motors

provide continuous-duty operation at 55 C rise

Form-G fractional-horsepower motors are totally enclosed, nonventilated, three-phase units rated from 1/4 to 3/4 hp and 220/440, 220/380, and 550-v. The 1/4-hp models are in NEMA frame sizes 48 and 56; all other models are NEMA frame size 56. Motors feature continuous-duty operation at

55 C rise; single-shielded ball bearings, large, built-in connection box, gunmetal-like shaft treatment that combats rust and corrosion; and a strong, steel base, securely welded to the shell to withstand shock and vibration. **General Electric Co.**, Schenectady 5, N. Y.

Circle 563 on Page 19

Stock Gears

are 20-deg pressure-angle units

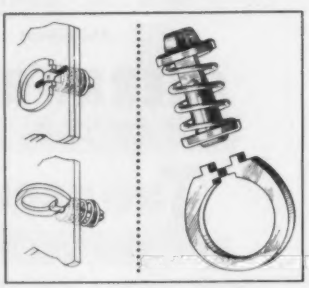
New stock gears are designed so that a 20-deg pressure-angle gear set will be interchangeable with a 14½-deg set, although single gears are not interchangeable. Gears are 3 to 20 pitch, in spur, bevel, miter sets (both straight and spiral), helical, and worm-and-gear sets. High-carbon steel, alloy cast iron, nickel bronze (worm gears) are used. Nonmetallic spur gears are available for low-load, high-speed applications. **Morse Chain Co.**, Ithaca, N. Y.

Circle 564 on Page 19

Spring-Loaded Latch

for removable panels and access doors

New spring-loaded latch can be used in any application requiring a quarter-turn sheet-metal fastener. Unit requires no riveting, screws,



in machine design or modernization...

Fawick FSPA improves machine performance

...with increased production through higher machine speed

Fawick Standardized Press Applications may be used as original equipment or for modernization on power presses and other machinery where productivity depends on cycling speed. Instant air clutch action and fail-safe braking allow faster operation without sacrificing safety or precision.

...precision control

FSPA provides split-second starts and stops that assure accurate automatic control of single, continuous or inching operations.

...manpower and machine protection

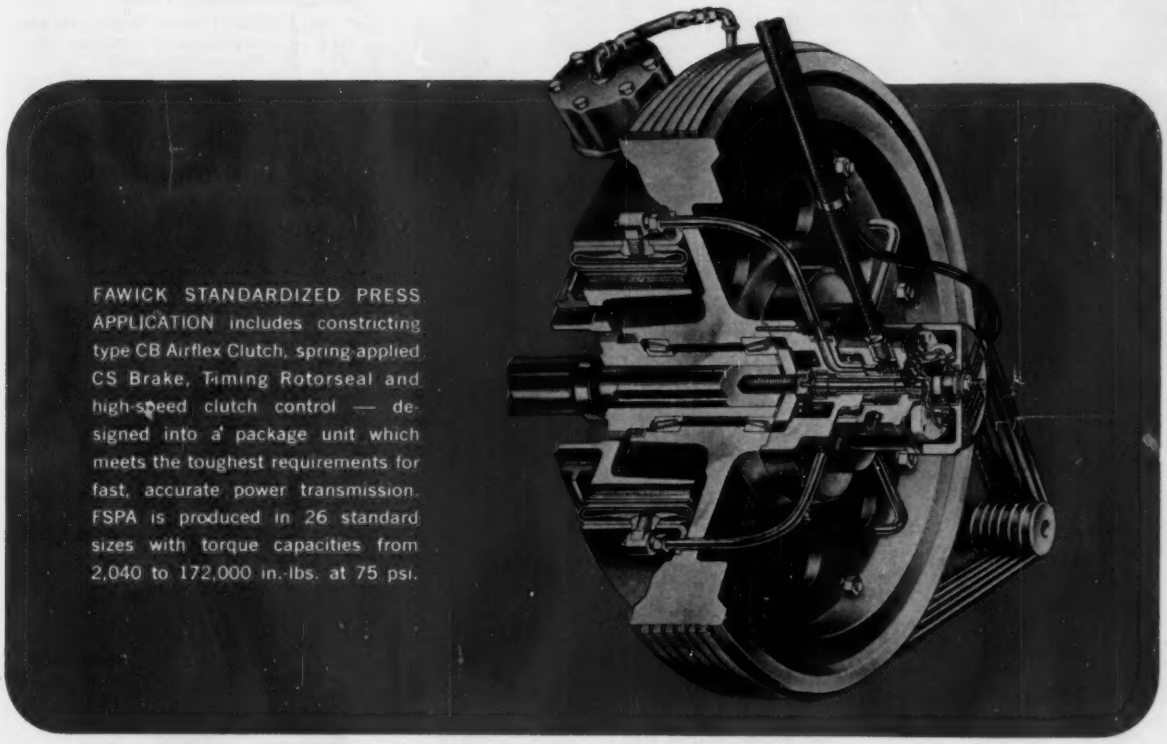
FSPA eliminates damaging backlash, providing maximum protection for intricate tooling. The spring-applied brake engages immediately in case of air or power failure, preventing costly jamming and insuring operator safety.

...installation flexibility

FSPA can be installed quickly and easily in both OEM and user applications. The package unit may be mounted on a common drum as shown below, or the brake may be mounted at another location on the shaft. Installation can be made with only minimum preparatory work.

...and unmatched low maintenance

Fawick drum-type air clutches have few moving parts and require no lubrication. The self-adjusting 360° friction surface insures long friction life and continuous new unit performance under the most demanding conditions.



FAWICK STANDARDIZED PRESS APPLICATION includes constricting type CB Airflex Clutch, spring-applied CS Brake, Timing Rotorseal and high-speed clutch control — designed into a package unit which meets the toughest requirements for fast, accurate power transmission. FSPA is produced in 26 standard sizes with torque capacities from 2,040 to 172,000 in.-lbs. at 75 psi.

For complete information on how Fawick can simplify your clutch problem, contact your nearest Fawick representative or the Home Office.

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Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX
INDUSTRIAL CLUTCHES AND BRAKES

Circle 335 on Page 19

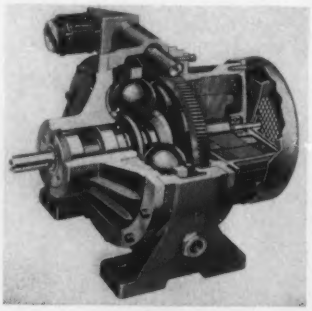
spot welding, or special tools. Spring tension eliminates noise transmission and vibration. Cadmium-plated latch has a wide application range accommodating thicknesses to 1/4 in. Monodnock Mills, San Leandro, Calif.

Circle 565 on Page 19

Motorized Speed Drive

in sizes from 1/3 to 15 hp

Utilizing an integral pancake-style motor, new motorized Speed Variator requires slightly more space than an equally rated conventional motor. Line is available in sizes from 1/3 to 15 hp. Motors are ac radial air-gap design and conform to NEMA B specifications. Unit provides variable output speeds



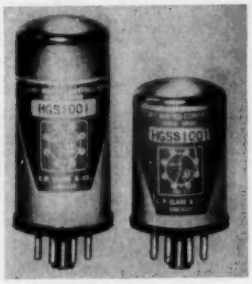
with 9:1 and 6:1 ranges. Employing the rolling action of a series of balls, it permits smooth adjustment of the output speed while operating under load. **Eaton Mfg. Co., Cleveland Worm & Gear Div.,** 3300 E. 80th St., Cleveland 4, Ohio.

Circle 566 on Page 19

Mercury-Wetted Relay

provides high sensitivity and speed

Type HGSS (right) mercury-wetted relay provides the same sensitivity and high speed of the HGS relay (left). Coil is fitted with side plates supporting two permanent magnets. Operating characteristics are established by adjusting the strength of these magnets after assembly. Broad range of single-side-stable, bistable, or chopper adjustments is available. Unit has freedom from contact bounce and good power-handling capabilities. It is suited for use as a high-speed chopper relay when



mounting space is limited. **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill.

Circle 567 on Page 19

Neoprene Contact Adhesive

gives bonds that are strong and resilient

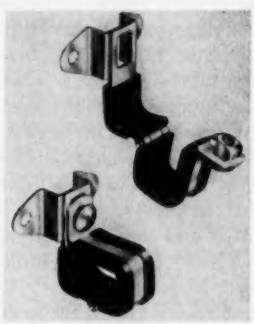
General-purpose neoprene contact adhesive, D-239, gives bonds that have high peel strength, remain permanently strong and resilient, and have good water resistance. Material bonds supported vinyl fabrics to metal, wood, and composition bases; thin-gage metals or foils to wood, cement asbestos board, hard board, and composition bases; and fabric-backed urethane sheets to metal, wood, and composition bases. Adhesive is a yellow, air-drying solvent type with synthetic-rubber base. It has a consistency of thin syrup and can be applied by brush, spray, or roller coater. It has good resistance to fatigue and has excellent aging properties. **Industrial Div., Armstrong Cork Co.**, Lancaster, Pa.

Circle 568 on Page 19

Rectangular Fasteners

incorporate fast-action key nut for securing

Flip-Loc fasteners in almost any



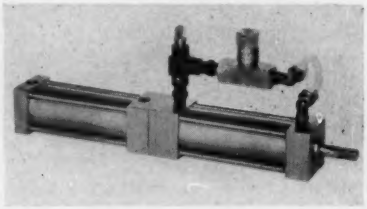
square or rectangular shape have a built-in hinge and fast-action key nut for securing the fastener and allowing any degree of mechanical take-up. Unit can be attached permanently and does not have to be removed from original installation in the open position. Once installed, fastener can be opened or closed indefinitely without fatigue on the metal. All components are captive. **TA Mfg. Corp.**, 4607 Alger St., Los Angeles 39, Calif.

Circle 569 on Page 19

Tandem Cylinders

in ¾, 1, 1⅛-in. bores

Tom Thumb air-oil tandem cylinders for maximum pressure to 200 psi are now available in ¾, 1, and 1⅛ in. bore, in eight mounting styles. Cylinders fill the requirements of the accurate speed control available in hydraulic cylinders, while having the advantage of being



air operated. Features include noncorrosive barrel, stainless-steel piston rod with lip-type rod seals, Delrin rod bushings, Teflon rod wiper and choice of O-ring or lip-type piston seal. **Tom Thumb Div., Pneumatic-Hydraulic Development Co.**, 317 W. Masterson, Fort Wayne, Ind.

Circle 570 on Page 19

Extruded Plastic Tubing

in sizes to 3 in. OD

Flexible or rigid vinyls, polyethylene, polypropylene, and other types of thermoplastic tubing are available in sizes to 3 in. OD. They are manufactured on spools, coils, or pieces accurately cut in lengths from 1/32 in. to 250 ft. Depending upon the type of application, tubing is extruded to meet exact wall thickness, ID, and other requirements. **Petro Plastics Co.**, 16 Quine St., Cranford, N. J.

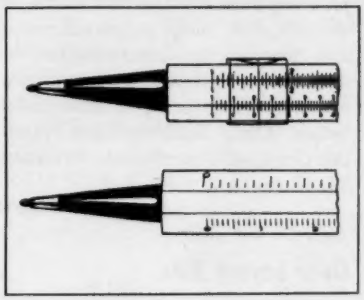
Circle 571 on Page 19

ENGINEERING
DEPARTMENT

EQUIPMENT

Combination Drafting Aid

is slide rule and mechanical drawing pencil



Jeff-Ette is a combination slide rule and mechanical drawing pencil. Slide rule has A, B, C, and D scales on face. Sides of the rule incorporate a 4-in. drawing scale divided into 32nds and a millimeter rule up to 10 cm. Slide rule performs multiplications, divisions, squares, and square roots. Small cursor unit has spring tension and fine hairline. Smooth-writing, mechanical-drawing pencil is 6 in. long, 7/16 in. wide, and 3/8 in. thick, complete with spring pocket clip. Combination includes leatherette sheath. **Alvin & Co. Inc.**, Palisado Ave., Windsor, Conn.

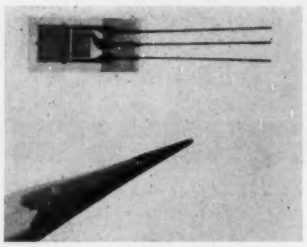
Circle 572 on Page 19

Strain Gage

has built-in computer

Bonded resistance-foil SR 4 strain gage has a built-in computer that solves general strain-to-stress equations automatically. Stress-strain gage provides electrical responses which are proportional to either stress or strain. Two independent axial strain-sensing elements are oriented 90 deg apart. One element measures conventional strain; the other acts as the automatic computer by rejecting the axial component of strain caused by stress in a transverse direction. Combined elements then respond only to that

Circle 340 on Page 19



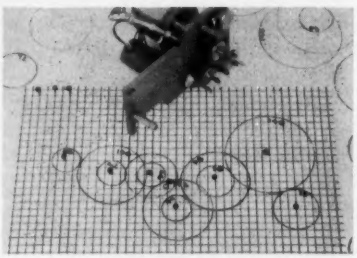
component of strain which is produced by stress in the axial direction. Gages are available with a phenolic-base construction and Constantan foil, with resistance ratios and temperature compensation for mild steels, stainless steel, and aluminum. **Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp.,** 42 Fourth Ave., Waltham 54, Mass.

Circle 573 on Page 19

Gear Layout Kits

in 48, 64, and 96 diametral pitch

New gear-train layout kits consist of an 8 x 10-in. layout board marked with 1/10-in. square grids, ten center pins color-coded for components identification, and 100 transparent gear discs. Kits are available in 48, 64, and 96 diametral pitch. In most cases, layout drawing can be eliminated completely by transferring the gear location dimension from the grid



board directly to an assembly drawing. **Advanced Designs Inc.,** 914 Lullaby Lane South, Vienna, Va.

Circle 574 on Page 19

True Compression Accelerometer

has range of 0.02 to 40,000 g

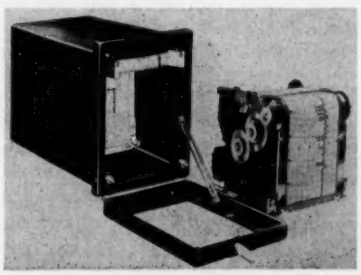
Model 706 accelerometer is a true compression-sensing device for measuring shock and vibration in missile and airborne vehicles and in

standard laboratory acceleration-measuring systems. Bolt-down mounting through a center clearance hole makes possible rotation of the output connector to any convenient direction in the plane perpendicular to its sensitive axis. Sensitivity of the unit is 35 mv per g, frequency response is flat within ±5 per cent from 0.2 cps to 10 kc, and resonant frequency is 60 kc. Acceleration range is 0.02 to 40,000 g, and amplitude linearity is ±1 per cent. Temperature range is −65 to +350 F for standard units, with less than ±10 per cent variation in sensitivity. Unit has stainless-steel ¾-in. case, is 0.53 in. high, and weighs 25 grams. **Columbia Research Laboratories,** MacDade Blvd. & Bullens Lane, Woodlyn, Pa.

Circle 575 on Page 19

Strip-Chart Recorder

miniature unit has accuracy within ±1 per cent



Without an amplifier, new A+ Record recorder requires only 400 mu w for full response within 0.6 sec. Produced with a 4500 gauss magnet flux, recorder permits obtaining of coil resistances and damping resistances matched to individual circuit characteristics. Accuracy is within ±1 per cent. Moving-coil ammeter or milliammeter withstands momentary overload of seven to eight times full scale. Panel-board space required is only 5½ x 7-1/3 in., or portable-type housings are also available. Zero adjust is from both front and rear. Chart drive and pen are reached from the front. Ink pen, hot wire, or Teledeltos wiring systems are available. **Atkins Technical Inc.,** 1276 W. Third St., Cleveland 13, Ohio.

Circle 576 on Page 19

THE ENGINEER'S

Library

Recent Books

Analysis and Design of Mechanisms. *By Deane Lent; 328 pages, 6¼ by 9¼ in., clothbound; published by Prentice-Hall Inc., Englewood Cliffs, N. J.; available from* MACHINE DESIGN, *$9.35 per copy postpaid.*

A graphical approach to the study of mechanisms is presented. Basic methods and techniques are emphasized.

Fundamentals of displacement, velocity, and acceleration are developed and applied to analysis and design of mechanisms. Analytic methods that can be applied to all mechanisms are discussed.

Weight-Strength Analysis of Aircraft Structures. *By F. R. Shanley; 404 pages, 5½ by 8½ in., paperbound; published by Dover Publications Inc., 180 Varick St., New York 14, N. Y.; $2.45 per copy.*

Methods of analyzing and predicting the structural weight of aircraft and missiles are discussed. This second edition includes developments which have occurred since publication of the first edition in 1952.

Topics include plasticity, dislocation theory, principle of simultaneous action, theory of creep buckling of columns, and the isochronous stress-strain method for determining buckling stress as a function of time. Original papers on inelastic buckling and creep buckling are also included.

Principles of Manufacturing Materials and Processes. *By James S. Campbell; 674 pages, 6¼ by 9¼ in., clothbound; published by McGraw-Hill Book Co. Inc., 360 West 42nd St., New York; available from* MACHINE DESIGN, *$9.75 per copy postpaid.*

Details of available manufacturing processes are presented in a comprehensive survey of the field. Measuring and gaging, heat treatment, sand molding, cleaning and finishing, welding, brazing and soldering,

melting, and rolling and forging are some of the techniques and processes covered. A separate chapter is devoted to recent developments such as electroforming, electrolytic grinding, chemical milling, ultrasonic machining, electron-beam welding and machining, and electric-discharge machining.

Numerical Methods of Curve Fitting. *By P. G. Guest; 422 pages, 6¼ by 9¼ in., clothbound; published by Cambridge University Press, American Branch, 32 E. 57th St., New York 22, N. Y.; available from* MACHINE DESIGN, *$15.00 per copy postpaid.*

This book presents methods of treating series of observations and draws upon both statistics and numerical analysis. In the first of three parts, the book deals with observations of a single variable ("curve" of zero degree) including the general theory, normal distribution, statistical tests, and discrete distributions. The second part covers the straight line including normal equations, statistical tests on normal law, and the independent variable subjects to error. The third part covers polynomials and other curves. It includes estimation of polynomial coefficients, standard deviations of the estimates, the grouping of observations, and general regression and functional relationship problems in several variables. Illustrative examples are included.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 161748. Steady State Damped Vibrations and Stability of a Class of Nonlinear Discrete Systems. By S. T. Chow and P. R. Sethna, University of Minnesota; 48 pages, 8¼ by 10¾ in., paperbound, stapled; $1.50 per copy.

A class of nonlinear discrete systems with an arbitrary number of degrees of freedom was studied for steady-state vibrations. Coordinates were first transformed to principal co-ordinates corresponding to linear part of system. Special effects of relations between linear natural frequencies on qualitative nature of solutions are demonstrated.

PB 161848. Corrosion of Superalloys by Selected Fused Salts. By A. Moskowitz and L. Redmerski, Crucible Steel Co. of America; 84 pages, 8¼ by 10¾ in., paperbound, stapled; $2.25 per copy.

Four nickel-base alloys and one cobalt-base alloy were studied to determine their susceptibility to fused-salt corrosion at elevated temperatures. Thin coatings of the salts—potassium chloride and lithium fluoride—were applied to Inconel X, Inconel 702, Rene 41, M-252, and Haynes 25. These specimens were then tested at temperatures of 1600 to 1900 F.

Circle 345 on Page 19

REPRINTS

Complete reprints of major article series and collections of articles, and extra copies of MACHINE DESIGN *Books*, are available from: Reader Service, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio. Remittance or company purchase order must be enclosed with your order. Add 3 per cent to orders in Ohio to cover State Sales Tax.

The Bearings Book, 1961 Edition (256 pp.) $2

The Seals Book, 1961 Edition (240 pp.) $2

The Fasteners Book, 1960 Edition (236 pp.) $2

Preventing Fatigue Failures, by F. B. Stulen, H. N. Cummings, W. C. Schulte, 1961 (32 pp.) $1 (available Aug. 1)

Simplified Vibration Analysis by Mobility and Impedance Methods, by R. P. Thorn & A. H. Church, 1959-1960 (80 pp.) $2

Inside the Engineer, by Eugene Raudsepp, 1958-1960 (52 pp.) $1

Mobility of Cross-Country Vehicles, by M. G. Bekker, 1959-1960 (32 pp.) $1

Engineering Approach to Hydraulic Lines, by Jaroslav J. Taborek, 1959 (36 pp.) $1

Planning New Products, by Philip Marvin, 1953-1958 (102 pp.) $3

Friction-Clutch Transmissions, by Z. J. Zania, 1958 (30 pp.) $1

Design Guide—Flexible Couplings, by Leo F. Spector, 1958 (128 pp.) $1

Special Report on Electric Motors, Staff Report, 1958 (42 pp.) $1

Electronic and Electric Power Supplies, (Symposium) 1958 (40 pp.) $1

Human-Factors Engineering, by J. D. Vandenburg and C. T. Goldsmith, 1958 (32 pp.) $1

Mechanics of Vehicles, by Jaroslav J. Taborek, 1957 (94 pp.) $2

Design for Fatigue Loading, by Joseph Marin, 1957 (34 pp.) $1

Hydraulic Servo Fundamentals, by J. M. Nightingale.
- Volume 1: May-Nov., 1956 (32 pp.) $1
- Volume 2: Nov., 1956—Mar., 1957 (30 pp.) $1
- Volume 3: May, 1957—Feb., 1958 (44 pp.) $1

Adjustable-Speed Drives (Electrical-Mechanical-Hydraulic), Staff Report, 1954-1955 (146 pp.) $2

MACHINE DESIGN Data Sheets
- 1960 (130 pp.) $2
- 1959 (136 pp.) $2
- 1958 (132 pp.) $2
- 1957 (102 pp.) $2
- 1956 (114 pp.) $2

Transactions of the Mechanisms Conferences
- Sixth Conference, 1960 (152 pp.) $2
- Fifth Conference, 1958 (240 pp.) $3
- Fourth Conference, 1957 (104 pp.) $2
- Third Conference, 1956 (40 pp.) $1
- Second Conference, 1954 (50 pp.) $1
- First Conference, 1953 (48 pp.) $1

Tips and Techniques
- Vol. 1—Drafting Aids, 1956-1957 (32 pp.) $1
- Vol. 2—Engineering Aids, 1956-1958 (30 pp.) $1

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **Hetron® for outboard motor shrouds**
- **Plastic potentiometer**
- **Dip-coating compounds**

Great for waterways

One key advantage of Hetron polyester resins is durability under stress. This quality turns out to be particularly pertinent for Gale Products, a division of Outboard Marine Corporation.

In the outboard motors produced by this Illinois firm, shroud permanency was a problem. The solution was to make them of Hetron reinforced with fibrous glass. A critical step in the production process consists of two baking operations at 240°F. The material takes the bakes without crazing.

In use the shrouds won't crack,

GALE PRODUCTS

craze, or corrode. They resist denting and abrasion, have high impact strength, are lighter than metal covers (about 3 lbs. lighter in the case of a 50-hp motor), protect motor parts from water spray, are about 15% less expensive to produce than metal covers.

An additional benefit is the transformation of the motor's roar to a pleasant purr, which permits boaters to enjoy conversation with their sport.

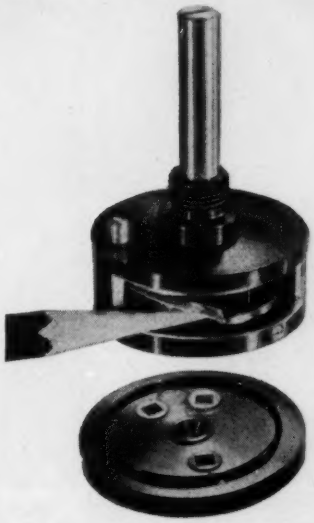
Hetron resins have properties that make for superior performance in a wide variety of applications. We'll be happy to send you detailed information on this family of premium polyesters.

Look—no coils

Get to the heart of a new and better product, and often you'll find a Durez plastic.

For instance: this little precision potentiometer. It's better because it's simpler—contains no resistance wire, no varnish, no cement to come unstuck and cause failure.

Instead, the metallic wiper (at pencil point) rides on an almost friction-free plastic ring, the resistance element. The



NEW ENGLAND INSTRUMENT CO.

ring is made of diallyl phthalate resin mixed with carbon. The buttonlike insulating base is a standard Durez diallyl phthalate molding compound.

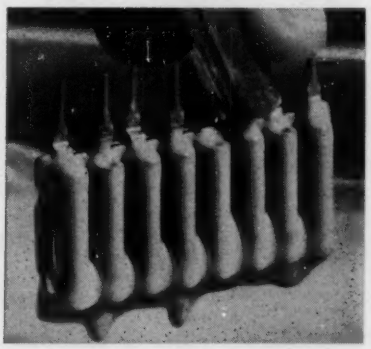
Potentiometers made with these materials just don't seem to wear out. Nor do they lose their excellent insulation properties in clammy surroundings. For these reasons, the little instruments are being specified widely for missile and rocket control systems, computers, and servo gear.

When your design project needs a moldable material of far-better-than-average electrical properties—*plus* resistance to moisture and heat—think of Durez diallyl phthalate molding compounds. We'll gladly send you facts about them.

Coat for components

Looking for a simple encapsulating idea? Here's one that works well at heatproofing, moistureproofing, and preventing shorts in small electrical components. It's non-messy, too.

Dunked in a paste coating, dried, then baked for a short time, components steadfastly resist extremes of heat and moisture that would otherwise raise havoc with their electrical reliability.



Components so coated can be soldered into a circuit without causing the coating to melt or peel. It won't soften, and easily passes a series of −55 to +85°C cycles. One thousand hours at a sweltering 150°C will turn the coating almost black, but still won't materially affect the component inside.

The paste is made with Durez phenolic resin-and-filler compounds supplied in powder form. After baking, it is impervious to ketone solvent cements sometimes used in assembling radio and TV chassis.

What can these dip-coating compounds do for you? We'd like to help you find out. Write for more detailed information.

For more information on Durez materials mentioned above, check here:

- ☐ Bulletin D-6: properties and applications of Hetron fire-retardant resins
- ☐ Data sheets: facts about diallyl phthalate molding compounds
- ☐ Data on phenolic resin compounds for dip-coating

Check, clip and mail to us with your name, title, company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

504 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Circle 347 on Page 19

Don't blindfold him!

THE MAN in this picture is a cancer research scientist. The device he is using looks like something out of science fiction—but actually, it's an electron microscope. It shows the sub-microscopic detail of a cancer cell—magnified 100,000 times. *The cost of one electron microscope is $35,000.*

Some of the equipment needed for cancer research is even more expensive.

Today, in research centers throughout the country, 1300 scientists, supported by American Cancer Society funds, are at work searching for the cause of cancer—and, ultimately, ways to prevent it.

The American Cancer Society grants millions of dollars for research on such projects as the study of viruses as a possible cause of cancer—the development of hormone treatments for cancer—the control of cancer by drugs. *Life-and-death projects.*

Your help is needed to enable the American Cancer Society to continue this support.

Don't blindfold cancer research. Give to it. Send your contribution now, to CANCER, c/o your local post office. All gifts are tax-deductible.

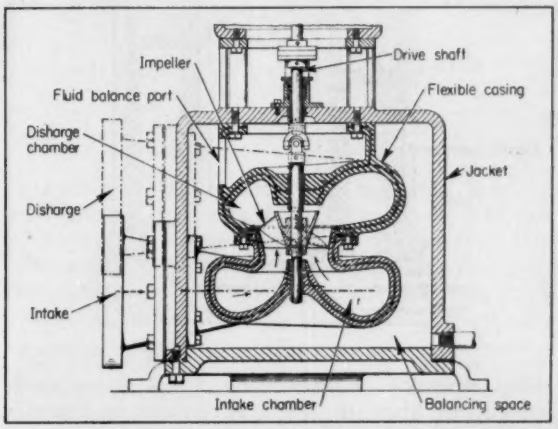
AMERICAN CANCER SOCIETY

NOTEWORTHY

Patents

Flexible Pump Casing

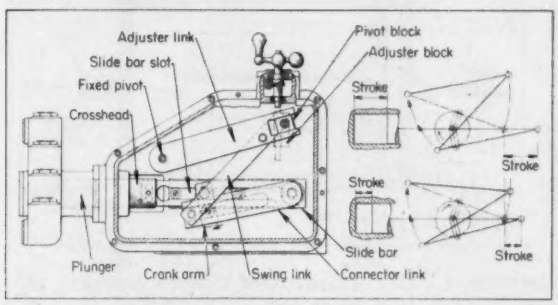
The casing of a centrifugal pump is made of flexible fabric-reinforced rubber to reduce noise and pressure pulsations. A rigid metallic jacket surrounds the casing. The space between the jacket and casing forms a balance chamber which is filled with a nonresonant material, such as gas under pressure or other compressible fluid. This gas or liquid is maintained at a pressure



substantially equal to the pressure in the intake chamber of the pump. Thus, the flexible casing and balance-chamber fluid work in combination to damp noise and pulsations arising from mechanical vibration, cavitation, or water jet impact. *Patent 2,973,716 assigned to C. H. Wheeler Mfg. Co., Philadelphia, Pa., by Louis G. L. Thomas.*

Variable-Stroke Linkage

Pivot points in a three-link assembly can be changed while a pump is running to alter the stroke of a reciprocating plunger. The effective length of each link



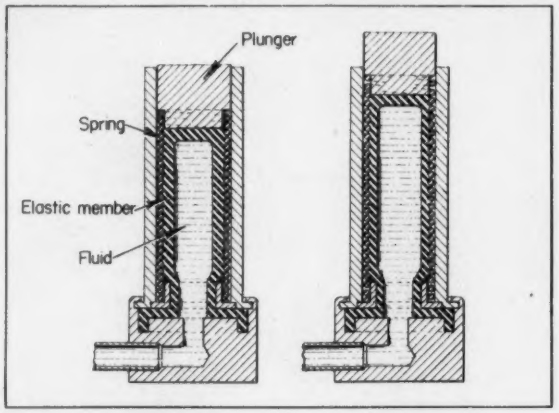
is equal and the left pivot of the adjustor link is fixed. Therefore, by raising or lowering the adjustor block,

Circle 349 on Page 19

the right pivot point of the adjustor link and both points of the swing link are changed relative to the path of the plunger. This change alters the position of the links to adjust the length of stroke from zero to maximum. *Patent 2,972,894 assigned to Milton Roy Co., Philadelphia, Pa., by Richard A. Bennett.*

Expansible Piston

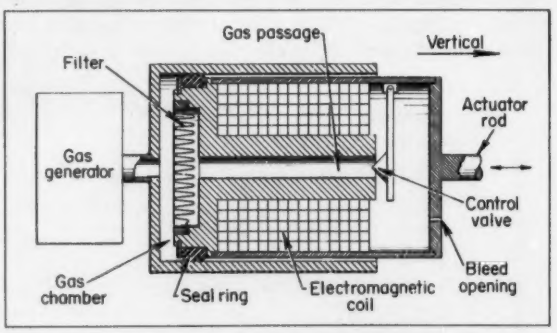
An elastic tubular piston expands and contracts under changes of fluid volume to actuate the plunger in a control device. The tube, of Buna-N rubber, is rigidly connected at the base by a flange and collar assembly. To prevent friction at the cylinder wall, a coiled brass spring surrounds the tube and prevents



radial expansion. Convolutions of the spring touch one another when the tube is at rest and the diameter of the spring wire is relatively small. Therefore, elongation of the tube causes only a slight separation of the adjacent convolutions. *Patent 2,973,644 assigned to Ranco Inc., Columbus, Ohio, by Frederick A. Greenawalt.*

Piston with Filter

In a gas-operated servo system the control valve in an actuator piston is protected from harmful products of combustion by a built-in filter. The filter is in

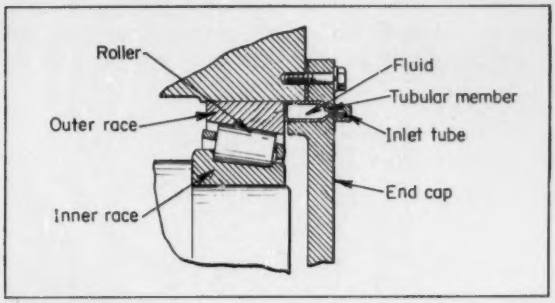


the form of a disc of corrugated sintered poromesh material and is held in the piston head by a retaining ring. Hot gas from the generator flows into the gas chamber and through the filter, where the solid by-

products of combustion are collected. After filtering, the clean gas flows through a passage to the control valve. This flow is controlled by an electromagnetic coil to meter the escape of gas through the bleed opening of the valve. *Patent 2,973,833 assigned to United States of America as represented by the Secretary of the Navy, by Harold G. Cook.*

Bearing Loading Device

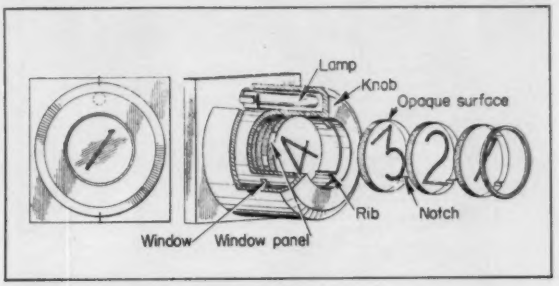
In a tapered-roller bearing assembly, a hollow synthetic rubber ring expands against the outer bearing race to provide axial loading. The ring is positioned



in a groove adjacent to the outer race which is free to move axially relative to the inner race. An inlet tube is provided to charge the ring with hydraulic fluid after assembly. As the pressure expands the ring in all directions a sidewise thrust against the outer race axially loads the bearing members. At the same time the bearing assembly is sealed against possible loss of lubricant. *Patent 2,972,504 assigned to The Timken Roller Bearing Co., Canton, Ohio, by John B. Baker.*

Shaft Position Indicator

A number of stacked transparent discs are provided with "windows" that permit illumination of etched numerals to indicate shaft position. The discs are posi-

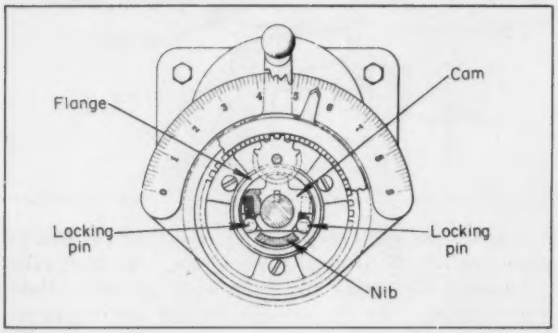


tioned within the inner sleeve of a knob attached directly to the shaft. A lamp is located within the outer sleeve of the knob. Each disc has an opaque circumferential edge except for a small rectangular window panel positioned vertically above the numeral. The inner knob sleeve is also provided with window slots which become aligned with the window panels

in a spiral sequence according to the angular position of the shaft. As each window is aligned, the cross-illumination of the lamp causes the rough surfaced numeral to be readily visible from the front of the knob. *Patent 2,972,978 assigned to Non-Linear Systems Inc., Del Mar, Calif., by William F. Collison.*

Shaft Positioning Mechanism

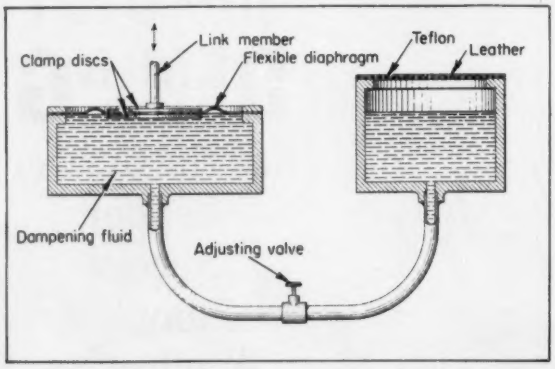
Two spring-loaded cylindrical pins wedge between a stationary flange and cam to prevent movement of an adjusting shaft in an adjustable-ratio transmission mechanism. The locking pins are located between a cam on the shaft and a nib projection on the hub of the positioning handle. The pins lock the shaft in



place at any handle position. A clockwise or counterclockwise rotation of the handle unlocks the pins to permit movement of the adjusting shaft. *Patent 2,973,070 assigned to U. S. Electrical Motors Inc., Los Angeles, Calif., by Edward P. Firth and Paul B. O'Reilly.*

Porous Plastic Air Vent

An exhaust breathing membrane of Teflon permits fluid expansion in a dashpot damping system with a rise in ambient temperature. The flow rate of the damping fluid is controlled by a valve located in the



conduit between the dashpot and an associated reservoir. Since the fluid level in the reservoir is the same as the level in the dashpot an air space is established at the top of reservoir. This air space is covered by the thin membrane of Teflon and leather. An increased volume

Typical steam forging hammer

REQUIRED SAFETY FACTORS in steering arm assured by designing it to be forged

By designing with forgings, a truck manufacturer can count on the required safety factors, with minimum "beefing-up" of parts to offset unknown internal structures or non-homogenious materials.

You, too, can achieve results like these by designing *with forgings* either at the start or on re-design. The benefits of forgings are equally impressive, whether you make home-workshop equipment or diesel engines.

Forgings start as *better* metal . . . are further *improved* by the hammer-blows or high pressure of the forging process.

Write for literature on the design, specification, and procurement of forgings.

When it's a vital part, design it to be FORGED

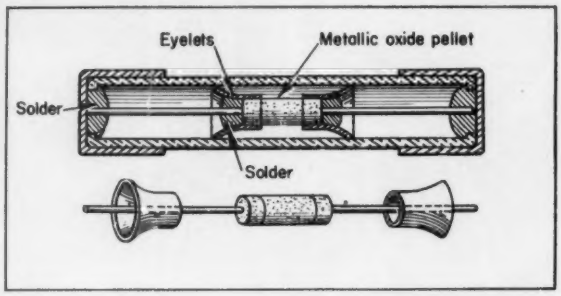
Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

of fluid, resulting from a temperature increase, causes the air to pass through the membrane while preventing dirt or other foreign matter from entering the system. *Patent 2,974,755 assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., by Konrad H. Stokes.*

Time Delay Fuse

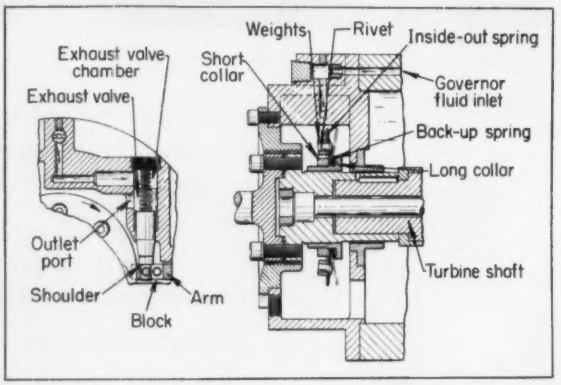
A metallic oxide fuse element provides a time delay of considerable length in small fuses. Normally conductive, the lead peroxide or bismuth dioxide pellet become substantially nonconductive when heated above



a predetermined value. Thus heated, the time required for a chemical change provides the time-delay feature. The pellets may be made in various sizes and shapes depending upon the load condition to be protected. *Patent 2,974,208 assigned to Sundt Engineering Co., Des Plaines, Ill., by Edward V. Sundt.*

Inside-out Spring Trip

A conical-disc spring "turns inside out" under centrifugal force to limit the speed of a turbine shaft. The spring completely encircles the shaft. At a predetermined speed, weights extended from the spring

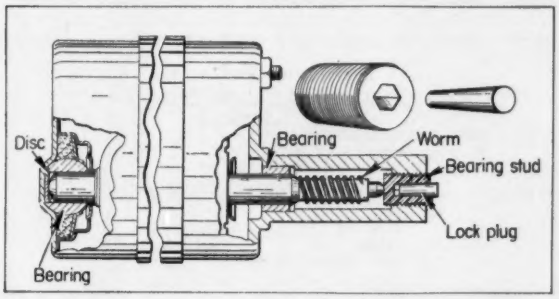


cause the spring to snap over by ventrifugal force. After the speed has been reduced, the spring snaps back to its original position. The spring motion acts in conjunction with a hydraulic exhaust valve to control fluid flow to the turbine control valve. A second, smaller conical-disc spring allows slight axial movement of the inner edge of the larger spring when it is snapped over. The device is accurate for speeds up to 100,000

rpm and can be mounted anywhere on the rotating shaft. *Patent* 2,973,771 *assigned to Carrier Corp., Syracuse, N. Y., by Eugene W. Barth and James R. Shields.*

End-Play Adjusting Stud

A nylon-stud thrust bearing is threaded for axial adjustment to control the end play in a small dynamoelectric machine shaft. The stud is slotted to receive a tool for axial positioning. When the stud is

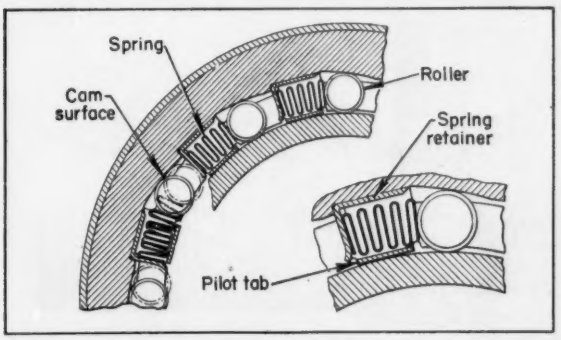


adjusted, a tapered plug is inserted to lock the stud with the housing. Because nylon is self-lubricating, the shaft rotates in a spherical seat in the stud end without excessive friction. *Patent* 2,976,088 *assigned to General Motors Corp., Detroit, Mich., by Peter R. Contant.*

Free piston fluid pump can be submerged in the fluid to be pumped. The free piston is reciprocated on a stationary conduit which acts as a piston rod through which the pressure fluid is conducted under mechanical control. *Patent* 2,974,601 *assigned to General Motors Corp., Detroit, Mich., by Joseph Zubaty.*

One-Way Clutch Assembly

Rollers are wedged between two races in a clutch assembly that permits rotation in one direction only. A one-piece, stamped retainer ring positions the rollers



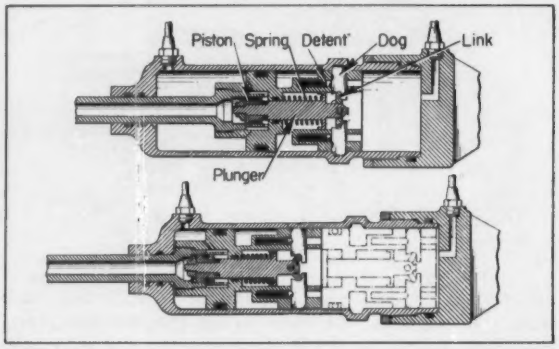
and associated flat springs circumferentially. Relative movement between the races in one direction causes the rollers to engage the cam surfaces of the outer race and to become wedged. However, movement in the

Circle 355 on Page 19

opposite direction unlocks the rollers to disengage the clutch. A pilot tab, placed at right angles to the retainer body, serves to pilot the inner race with respect to the outer race. *Patent 2,973,874 assigned to Ford Motor Co., Dearborn, Mich., by Thomas R. Stockton.*

Midstroke Locking Device

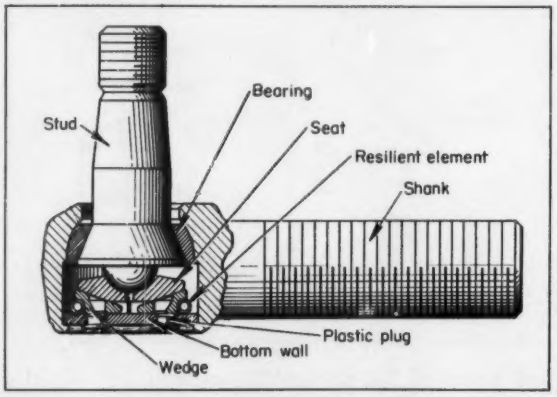
Internal dogs lock a hydraulic piston at midstroke and are retracted by application of hydraulic pressure to the cylinder. Movement of the dogs is controlled by a spring-loaded plunger connected to the dogs by toggle links. Axial movement of the plunger to the



left causes the toggle links to swing inward thereby retracting the dogs. The plunger is moved by hydraulic pressure; fluid enters from the left end of the cylinder through a port in the piston, while the right end of the plunger is directly exposed to pressure from the right end of the cylinder. Therefore, pressure applied at either end always moves the plunger to the left to retract the dogs. When pressure is removed the dogs are extended to locking position by the plunger spring. *Patent 2,974,638 assigned to Western Hydraulic & Service Co., Inc., Gardena, Calif., by Richard A. Chace.*

Spring-Wedge Stud Support

To minimize wear and effects of perpendicular load forces, the stud in a ball-joint assembly is supported by a spring-wedge seat. A garter spring is placed around

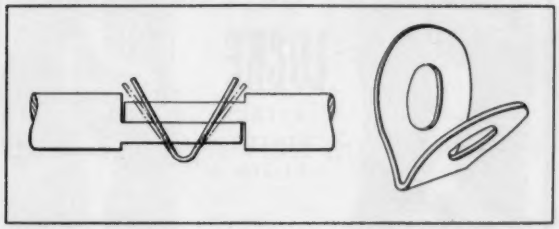


the wedges to load them radically inward. This action in turn, cams the seat upward. Since the angle of

inclination of the wedge surfaces is relatively small, the horizontal component of any forces tending to unseat the stud is decreased. Spring tension is sufficient to hold the wedges in position without producing undesirable binding at the bearing surfaces. *Patent* 2,972,496 *assigned to Thompson Ramo Wooldridge Inc., by Edward J. Herbenar and Sylvester S. Mazur.*

Spring-Clip Flexible Coupling

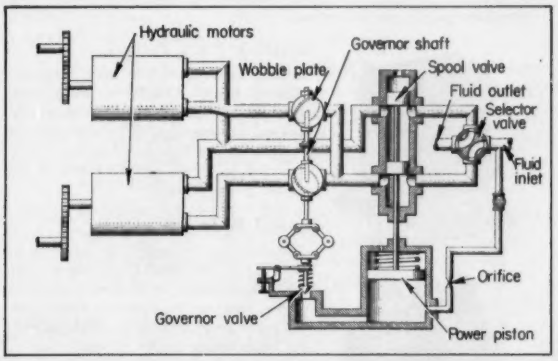
A simple V-shaped spring-clip coupling for small-diameter shafts is mounted in place without fasteners or other auxiliary parts. Legs of the clip have holes to receive the shaft sections. The overlapping ends of the



shafts are provided with flat driving surfaces. The legs of the clip are first flexed toward each other for assembly of the shaft ends. When released, the legs spring out to grip the shaft surfaces. *Patent* 2,971,355 *assigned to National Co. Inc., Malden, Mass., by John A. Walsh.*

Pneumatic-Motor Synchronizer

Wobble plates in a governor for pneumatic motors are connected in tandem to synchronize control actions. In operation, a spool control valve is opened by inlet fluid pressure acting against a power piston. The operation of this piston is regulated by a governor bleed-off valve. Variations in the rate of flow to the



motors are sensed by the wobble plates to adjust the amount of bleed-off opening. Because the wobble plates are coupled together, any tendency of either motor to vary is sensed by the one and transmitted to the other, thus insuring synchronous operation. *Patent* 2,972,869 *assigned to The Garrett Corp., Los Angeles, Calif., by Raymond W. Jensen.*

Circle 357 on Page 19

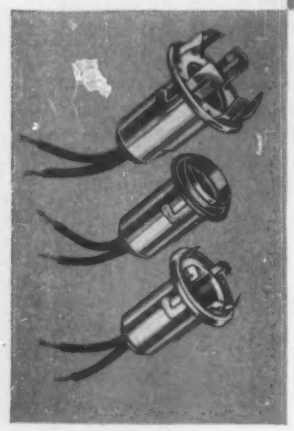
CUSTOM-ENGINEERED SNAP-IN AREA LIGHTS AND LAMP SOCKETS

Compactly designed for flush mounting

Recommended for use in freezers, refrigerators, athletic score boards, theaters, marine equipment. Adaptable to virtually any use in which space saving, durability, style and light concentration or dispersion are important. Variety of lens types and colors available. 1¾", 2", 3" dia. assemblies. U. L. approved. 75w, 125v.

Multi-directional light distribution

Recommended for use in Hi-Fi equipment or in laundry and kitchen equipment. Standard part has stainless steel face plate for snap-in or screw-in mounting, specially fluted lens for multi-directional lighting. Modifications permit single light to be used for inside-and-outside or multi-compartment lighting. 3⅛" x 25/32" mounting aperture. U. L. approved. 75w, 125v.



Durable, snap-in, crimp-in, lock-in sockets

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ELECTRICAL DOT ASSEMBLIES

The UCINITE COMPANY

Division of United-Carr Fastener Corp.
Newtonville 60, Mass.

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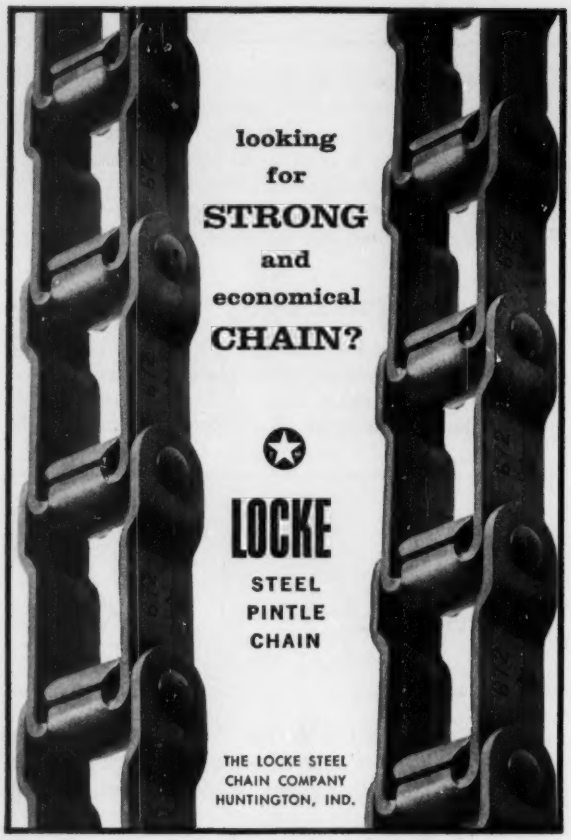

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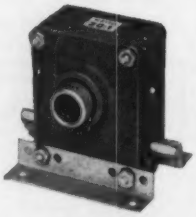
NEW-TYPE FHP PULLEYS AND SPEED REDUCERS SAVE YOU 33% PER UNIT

You can now cut costs on fractional horsepower equipment of all kinds with these unique, metal and nylon-fiberglass products. Rampe Variable Pitch Pulleys and Speed Reducers wear longer, run quieter, and cost less. Savings are 33% or more per unit in lower initial cost and added chemical resistance, impact strength, self-lubrication for hard-to-reach applications.



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Speed Reducers

Complete line includes gear ratios up to 1500 to 1. Machined steel worm gear drive shaft, choice of aluminum or nylon output gear, in fiberglass reinforced case. ½" solid or hollow shaft. Model SW-1, for applications up to ¼ hp.

Send for latest catalog sheets containing complete details on Rampe fhp products. See how you can save with better performance at lower cost.

RAMPE MFG. CO.
14915 WOODWORTH AVE., CLEVELAND 10, OHIO

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NYLOK makes any threaded joint reliably self-locking.

Any shape, any size, any material, male or female . . . if it's a threaded joint, it can be made to:

LOCK . . . against conditions of vibration and shock

SEAL . . . against fluid leakage along the threads

ADJUST . . . prevailing torque keeps it exactly where you wrench it . . . without being seated

How? Through the application of the patented principle of Nylok fasteners which makes it possible to achieve the torque *you* desire . . . together with the ability of Nylok engineers to adapt this principle to solve any problem of loosening in a threaded joint.

Your product . . . and your reputation . . . suffer with every loosened fastener. The best and most economical insurance against malfunction caused by fastener loosening is a Nylok engineered fastener. Billions of them are now in service in thousands of applications ranging from eyeglass temple screws to missile nose cones. MIL-F-18240A (ASG) states that Nylok fasteners are recommended to replace lock-wiring in aircraft and missiles.

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SEND FOR SAMPLES: Describe your application and our fastener specialists will analyze your problem and recommend a solution and they'll send you samples of Nylok fasteners. Write to Dept. N1-14.

FREE DESIGN DATA:
Circle the indicated number on the Reader Service Card, and we'll send you a copy of our 24-page catalog, giving complete, basic product and application data.

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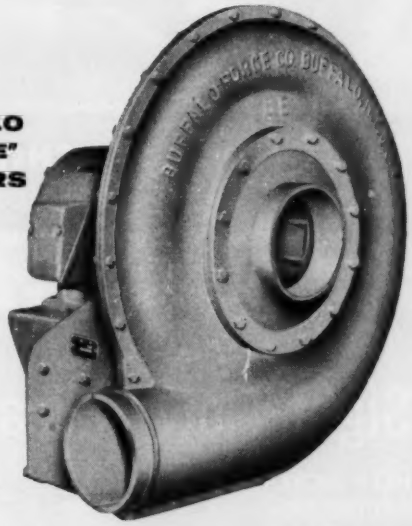
YOUR EQUIPMENT DESERVES BUFFALO QUALITY BLOWERS!

There are 3 simple checks to be sure that the blowers you design into your product are right. Certainly, a blower should last the life of the equipment. It should deliver rated capacity. And it should be compact, trouble-free and efficient.

Buffalo, experienced builder of every type of fan for both Original Equipment and for major air handling systems, has designed this "Q" Factor* of Quality into every fan bearing the name. For this reason, a Buffalo Fan, designed for the job, is your assurance of superb, worry-free performance in the air-moving function of your equipment.

BUFFALO TYPE "E" BLOWERS



For medium-volume, medium-pressure applications, there is no better buy than "E" Blowers. Husky housings, interchangeable for clockwise or counter-clockwise rotation. Wheels available in Cast Iron, Stainless, Everdur, Brass or Aluminum. Capacities to 5500 cfm; pressures to 1¾ psi. Compact, direct-connected arrangement for best installation. Write for Bulletin FI-410 and judge for yourself.

**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

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Sales Representatives in all Principal Cities

INDUSTRIAL EXHAUSTERS • BELTED VENT SETS
PROPELLER FANS • "E" BLOWERS-EXHAUSTERS

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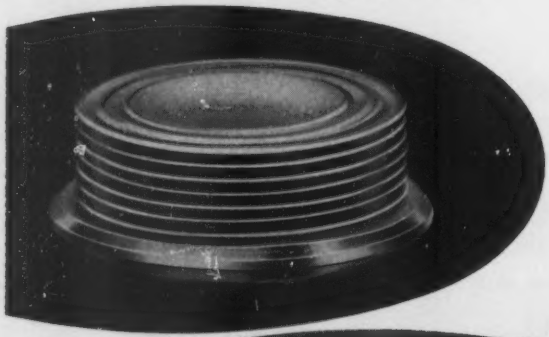
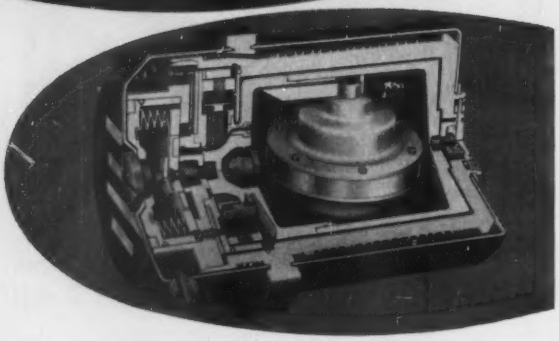
Circle 362 on Page 19

WELDED DIAPHRAGM BELLOWS
Engineered By

METAL *Bellows*

Selected by Minneapolis-Honeywell For New Gas-Bearing Gyroscope





The complex new gas-bearing gyroscope shown here in a cut-away has a bell-shaped ceramic spin motor. Its interior spins at 24,000 revolutions per minute suspended on a film of helium gas only 25 millionths of an inch thick. The gyro weighs just 8 ounces, is 2.8" long and 2.0" in diameter.

Here is what the Welded Bellows Assembly Selected provides in this Minneapolis-Honeywell gyroscope:

1. Short nested length for long stroke and greater volumetric compensation.
2. Low spring rate resulting in minimum changes in pressure of the fill fluid over full temperature range.
3. Excellent spring characteristics eliminating the possibility of cavitation in fill fluid at the low temperature end.
4. Leak tightness.
5. Long bellows life and reliability.

Design and manufacturing services in full depth now available to West Coast customers from our Pacific Coast Division.

Ask for design data literature for volumetric compensating bellows.

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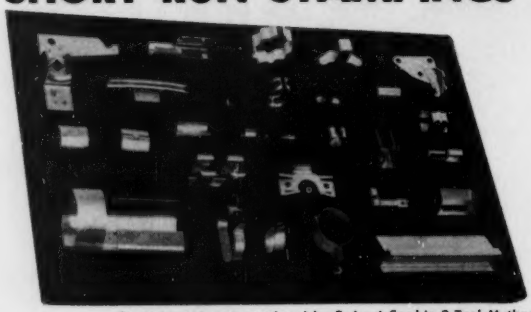
Pacific Division: 20972 Knapp Street, Chatsworth, California

New Federal Combin-O-Tool Method SAVES UP TO 46% ON SHORT RUN STAMPINGS



Some typical parts produced by Federal Combin-O-Tool Method

Combined operations mean lower cost short run stampings whenever they can be produced by the Federal Combin-O-Tool Method.
Where it formerly took 4 or 5 operations—it can now be done by Federal with only 2 or 3 operations. The labor savings are passed on to you in lower cost stampings. Send your prints or parts today to see if they can be done with the new Federal Combin-O-Tool Method. The savings will please you.

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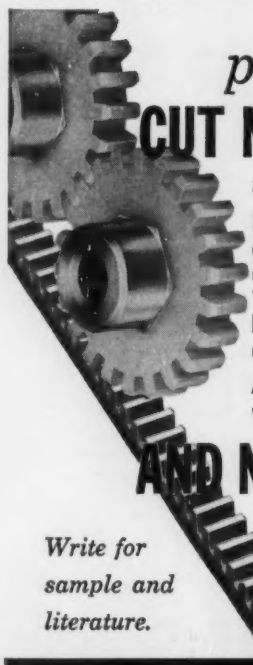

precision CUT NYLON GEARS
with metal insert hubs

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Also molded "Hexlok" pulleys, worm gears, ratchets, rollers, etc.

AND NYLON RACKS

From stock, cut tooth nylon rack with 14½° and 20° pressure angle. Pitch range 16 to 48, lengths to 24-in.

Write for sample and literature.

CLIMAX METAL PRODUCTS CO.

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Circle 371 on Page 19

NOW...Increase Machine Production ...Improve Worker Safety

New GLEASON

ECONOREEL

AUTOMATIC CORD TAKE-UP

Longer cord service, smoother action, improved operating convenience, less production downtime — are only a few advantages of New Gleason ECONOREEL on your electric powered hoists and other equipment-in-motion. Built to outlast ordinary reels, ECONOREEL has many unique features: new heavy duty 4-pole collector and brush assembly with interlocked collector rings, safety terminal block; replaceable spring motor with adjustable tension; adjustable holding dog; prelubricated bearings; two-way payout, plus many accessories. Heavy 20 Amp. capacity, for voltages to 550 AC, 250 DC; handles 2 to 4 conductor No. 18 to 12 A.W.G. cord up to 45 feet in length.

Write for new bulletin No. R161 for illustrations and technical details.

Gleason Reel Corp.

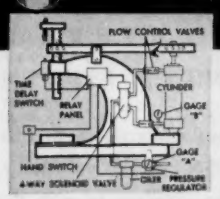
Dept. B, 900 Horicon St., Mayville, Wis.
Represented in Principal Cities

Circle 372 on Page 19

PNEU-TROL

AUTOMATION TIME DELAY SWITCH

FOR CONTROLLED TIME DWELL OF AIR OR HYDRAULIC CYLINDERS



Arbor press converted to high production power press, using double end cylinder, Time Delay Switch, Flow Control Valves, and related equipment, Flow Valves permit independent ram speed adjustment in both directions. Differential pressure between "A" and "B" gages caused by throttling effect of Flow Control Valve creates time interval in working pressure build-up, which is compensated for by Time Delay Switch setting. This insures consistently accurate working pressure on the ram.

- **Holds dwell accurately to fraction of second**
- **Automatically re-sets**
- **Designed for millions of actuations**

Pneu-Trol Time Delay Switch will hold any cylinder controlled motion or operation at a positive stop on either end of the stroke for ¼ to 60 seconds in 20 to 1 ratios. Simple, easy to adjust. Automatically re-sets after each actuation. Positive, controlled time dwell permits wider use of air or hydraulic power in automatic operations, increases accuracy of work by insuring split-second accuracy of time dwell. Available with many thrust linkages for left and right, down, up, or horizontal thrust. Write for Special Bulletin TDS-59

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NATIONAL LOCK

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National Lock offers superior engineering and design ability, plus extensive, up-to-date production facilities, to manufacturers in all phases of American industry. The broad knowledge gained in serving these varied customers can serve you, too. Look to National Lock when you need fasteners and decorative or functional hardware of the highest quality. Write today for full information.

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13 E. 40TH ST. NEW YORK 16, N. Y.
CABLE: ARLAB

Circle 374 on Page 19

ENGINEERS
AVAILABLE OR WANTED

WANTED: Development Engineer. Research laboratory of large steel producer in western Pennsylvania offers outstanding opportunity for a graduate Mechanical Engineer with experience in development and design of metals-processing equipment and with facility in oral and written communications. Forward complete information including salary requirements to Box 992, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

WANTED: Development Engineer. Develop advanced manufacturing production equipment and systems for widely varying applications. High analytical, technical and inventive abilities required plus minimum of five years experience in design of production machinery and controls. M.E. degree required with additional consideration given advanced degree. Send resume and salary requirements to: Mr. Howard E. Lutz, Jr., Westinghouse Electric Corporation, P. O. Box 2278, Pittsburgh 30, Pennsylvania.

WANTED: Chief Engineer. Leading manufacturer of highly engineered metal working machines seeks outstanding man to direct all engineering functions. Must hold a degree in mechanical Engineering or equivalent, and have a thorough design and related engineering background. Ability to administer a large department and lead people is essential. Location in large midwest city. This challenging position offers salary commensurate with opportunity. Reply in full, including earnings. All replies will be treated in strict confidence. Box 991, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

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BPA NBP

backtalk——

— Astral Aspirants Nix Nicotine

Cigarette advertisements will never show a picture of an astronaut relieving his post-orbital tensions with tobacco, because spacemen will not be smokers. This latter conclusion was reached by Aerojet-General Corp. scientists, who say that smoking would place too great a stress on the air purification system of a space ship or suit—present models, at least. The occupant of a space capsule who yields to the urge to have a cigarette—and fills the cabin with tars, nicotine, carbon monoxide, and partially burned hydrocarbons—will be taking his last ride.

A former smoker is likewise not a candidate for space travel, according to the Aerojet researchers. Their conclusion (issued before ex-smoker Yuri Gagarin reported that his ride was really quite enjoyable) was that a spaceman would have enough problems without having to cope with wanting to smoke and not being able to.

Moral: If you smoke, don't soar.

— Dept. of Circumstantiation

If you read your last issue carefully, you must have noticed that two new features have been added to MACHINE DESIGN.

The first that you will come to, reading backward from here, is the Reprints column on Page 210. This will follow our familiar Engineer's Library department and will list MACHINE DESIGN *Books* and the series and other collections of articles which have been reprinted. In some cases a reprint still in the embryonic stage will be listed so you'll know what's coming. "Preventing Fatigue Failures," for instance, is a six-part series that starts on Page 116 of this issue. The reprint, which will be available about the first of August, can be ordered any time.

Now for the free stuff. Our other new look is on the Reader Information Service listings and cards, Pages 17-20. If you want a copy of an article, just circle the "Editorial Article" key number on the post card. The numbers—with titles and brief descriptions of each article—are also on Page 18. You will notice that, along with the 9-1, etc., listings for this No. 9 issue, popular articles from previous issues are also mentioned. Helpful Literature and New Parts and Materials items are now listed according to product area. Further information on these items and on the ads is obtainable, as before, by circling numbers on the cards.

Any questions? Just jot them down, draw a circle around them, and send them in.

— Another Go (on Two Wheels)

An automobile designed by advanced stylists at the Ford Motor Co. would travel on half as many wheels as the majority of motorcars (see Page 32). This Gyron, however revolutionary it appears, is not the first car with such sparse underpinning.

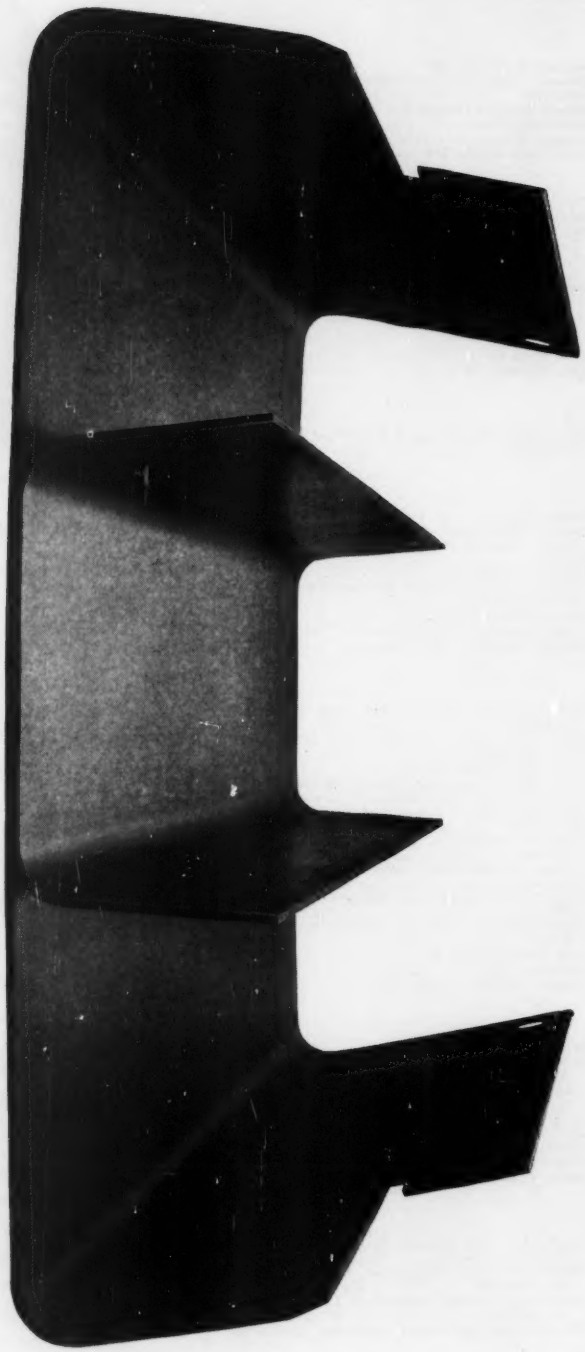
Back in ought-eight, James Scripps Booth, an automaker who was very much advanced for his time, built a Bi-Autogo. Like the Gyron, this car was to depend on a gyroscope for balancing on its two wheels. Two big problems kept the Bi-Autogo from ever really going: Steering, and operation of the small "landing" wheels that balance the car when the gyro has been inactivated. The Gyron, of course, can use hydraulic systems for these jobs, but it has a rather major problem (financial) of its own. Back in Booth's day, the two-wheeler idea was called "a fascinating engineering challenge." That much, at least, has not changed.

— Preview of a Preview

The next issue of MACHINE DESIGN (May 11) will include a section devoted to the sixth Design Engineering Show and Conference. This event—*the* show for most design engineers—will take place in Detroit's new Cobo Hall May 22-25.

Twenty-six papers will be presented during the ASME-sponsored conference sessions, and hundreds of exhibitors will display thousands of products. Our preview will be in the form of a Show Guide, so that you can plan ahead if you're going to the show—or see it on paper if you're not going.

Advertising Index



Practical approach to compactness is demonstrated by this flame retardant, interphase insulating barrier for magnetic air circuit breakers. When the equipment was designed, CDF utilized its extensive knowledge of adhesives and post-forming to provide the barriers from a flame retardant, paper base phenolic laminate.

Result: two pieces bonded together to provide three channels in one unit, reducing size and cost, yet maintaining effective electrical insulating properties.

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Flame resistance: ASTM D-635
... self extinguishing
Water absorption, % 1.8
Flexural strength, psi 12,000
Specific gravity 1.38
Dielectric strength, parallel, kv . . . 40

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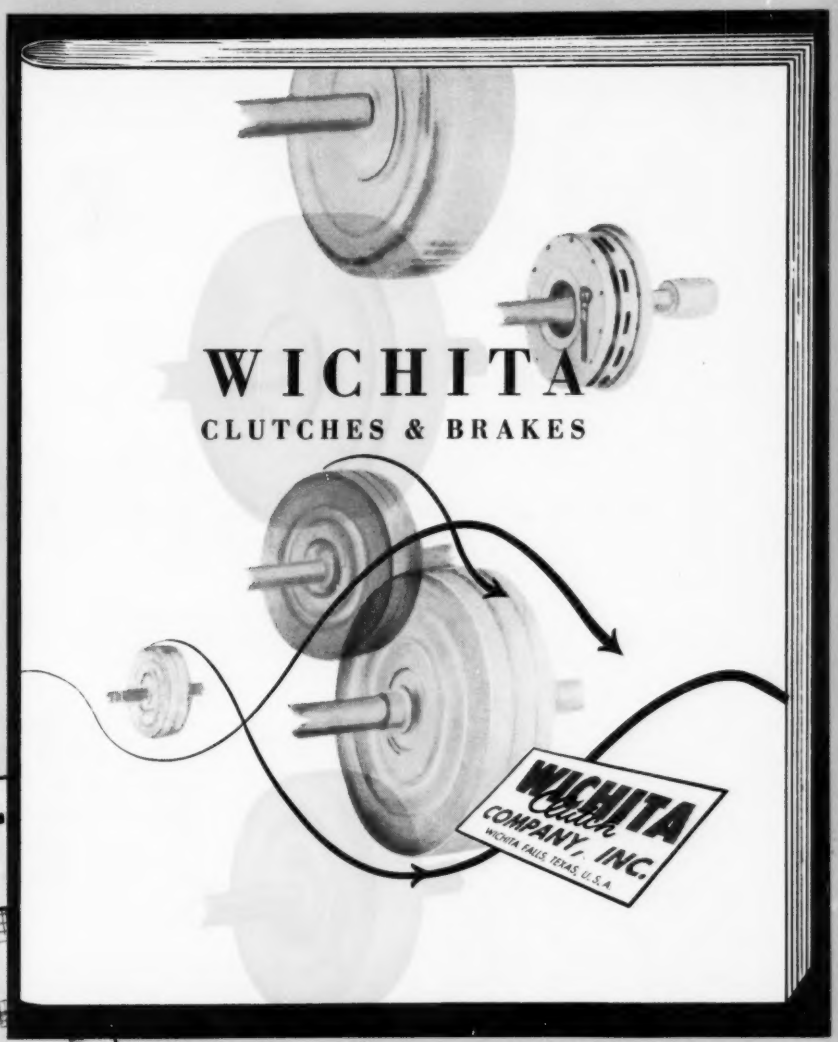

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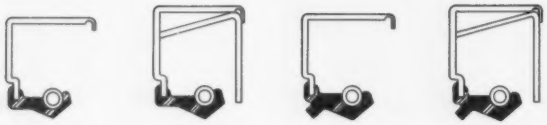

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The CRS Seal now provides a new level of C/R Seal performance through its simple, bonded design. There are no internal parts to misalign, no avenues for internal leakage. The shell and sealing member are integral — bonded securely for the long life of the seal. The CRS Seal incorporates a sealing member with both improved lip configuration and improved concentricity. The sealing member has been strengthened over former designs by placing more material at points of major flex and wear — and without increased shaft loading.

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The CRS Seal gives the designer one, basic, rugged shaft seal design which may be applied with high reliability to the great majority of common shaft seal applications — particularly in industrial, automotive, farm, and off-the-road equipment.

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Selection of the new C/R Type CRS Seal gives the designer and buyer major advantages over special seals: shorter lead time on orders, simpler specification, savings in time and money, and improved assembly quality and reliability.

Operating Maximums*

Shaft Speeds	3600 fpm (single lip) 2500 fpm (double lip)
Run-out	.016" TIR dynamic eccentricity .010" static eccentricity
Temperature	−30 to +275°F. (225°F. in EP lube)
Pressure	5 psi (single lip) 10 psi (double lip)
Media	Oil, grease, fuel, water

**Not all conditions present in one application*

New, Improved Compound

Standard sealing members for the C/R Type CRS Seal are molded of a new Sirvene synthetic rubber compound having markedly superior sealing and wearing properties. It is a Buna-N-based material with low-friction characteristics. The CRS Seal can also be furnished in the usual special materials such as acrylates, Silicones, and butyls. Shells are of standard steel, but can be provided in corrosion-resistant materials on special order.

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For assistance on the application of the new CRS — or on any oil seal problem, get in touch with C/R Oil Seal Engineers. They're specialists in fluid sealing — and will gladly cooperate with you.

For More Design Data:

You will want the complete design data on the new CRS Seal. Write for our Bulletin CRS-100. It gives you the complete list of standard sizes, widths, O.D.'s, shell thicknesses and sealing lip heights. You will want it to compare and then specify C/R's CRS Seal.

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Circle 203 on Page 19